Edinburgh Chamber of Commerce

1859

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With the Author's compliments.

TWO LECTURES

DELIVERED BEFORE THE

Edinburgh Chamber of Commerce.

II.

PRESENT STATE OF THE LONGITUDE QUESTION IN NAVIGATION.

[*Tuesday*, the 26th *April* 1859,]

By Professor C. (Charles) PIAZZI SMYTH, Astronomer *Royal* for *Scotland*.

WITH A

BRIEF HISTORICAL ACCOUNT OF THE CHAMBER.

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EDINBURGH:

PRINTED FOR THE USE OF THE MEMBERS.

THE EDINBURGH CHAMBER OF COMMERCE:

A SHORT HISTORICAL ACCOUNT OF ITS RISE, PROGRESS, AND PRESENT POSITION.

¶ *The opportunity afforded by the publication of the Lectures of* Mr Sheriff Hallard *and* Professor Piazzi Smyth (*which are printed and circulated at the expense of* Mr Lawson, *the esteemed Ex-Chairman of the Chamber*), *enables the Directors to give circulation to the following, which has been drawn up with the view of affording to the Members and to the commercial public generally, a short account of the origin, progress, and present position of the* Edinburgh *Chamber of Commerce.*

Origin

IN the latter end of 1785, Mr *David Steuart*, banker, first suggested the idea of establishing a Chamber of Commerce in *Edinburgh*; and, finding it approved by several mercantile gentlemen, he called a meeting of those favourable to the scheme, in the New Church Aisle, on the 21st *December* of that year. One hundred and eighteen persons accordingly met; and among the names of those present, we find those of the Earl of *Roseberry*, Sir *John Inglis* of *Cramond*, Bart., Sir *William Forbes* of *Pitsligo*, Bart., Sir *James Hunter Blair*, Bart.; Messrs *John Hay*, *Robert Allan*, *George Kinnear*, *William Ramsay*, *Andrew Bonnar*,

nar, and *Alexander Bonnar*, bankers; *Walter Hog*, manager of the *British* Linen Company; *William Fettes*, *Thomas Gladstone*, and *John Cadell*, *Cockenzie*, merchants; *John Haig* and *James Haig*, distillers; *Alexander Crichton*, coachmaker; *John Learmonth*, and *John Learmonth*, jun., tanners; *William Creech*, bookseller; and many others, whose names were then, or subsequently became, known throughout the whole commercial circles of *Scotland*, and some of whom have attained even a wider reputation.

It may be interesting to notice, that the last survivor of the original founders, Mr *Adam White* of *Leith*, was one of the Deputy Chairmen in 1842 and 1843, and died while in office.

The meeting seems unanimously to have approved of the proposal to establish the Chamber; for, after Mr *Steuart* had submitted to the meeting some regulations for the conduct of the proposed institution, a committee was appointed to revise the laws proposed, and report to another general meeting, and Mr *Creech* was requested to write a preamble or introduction.

Mr Creech's preamble

At a subsequent meeting, the introduction and rules were read and approved of. The former, in the somewhat ambitious phraseology of the period, states:—

"SCOTLAND, which in times past could scarcely be considered in any other light than that of a warlike nation, has of late years made rapid advances in trade and manufactures. The great body of the people, while under a feudal system, were engaged either in national contests or in civil broils. Commerce and the arts of peace were little cultivated: and absence from the field was generally passed in indolence, and improvement lost in inactivity. Those days, however, are now happily over; and the present spirit of trade, and of rising manufactures, which actuates this country, must be highly pleasing to every patriotic mind. To support and regulate this growing spirit of industry becomes an object of national concern; and it will be felt as a duty by every good citizen.

"If

"If ever there was a time when attention to Trade and Manufactures was necessary, it is the present: at the end of an expensive war, with an enormous load of national debt, heavy taxes upon every article of life or convenience, and the treaties of commerce with *Ireland*, *France*, and *America*, unsettled.

"It is only by united virtue, and united industry, that such a situation can be raised to prosperity and eminence; and Societies of men exerting their efforts to this noble purpose, deserve the applause of every well-wisher of his country.

"It must be obvious, that a Society of Merchants and Manufacturers, with united liberal views, may be highly useful to Commerce. They may, as a body, establish plans and systems that may greatly contribute to improvement, and check others that might be detrimental; but which, as individuals, they would neither have planned, nor had ability to execute.

"The increase and improvement of Trade and Manufactures is also deeply connected with the Landed Property; and every advancement in the first has an evident tendency to promote the interest of the latter.

"The protection and encouragement of Commerce and Manufactures, and the rules and practices of Merchants, have hitherto been little attended to in the code of our municipal laws. It was even lately found, that the sinking of ships wilfully could not be punished as felony; and this crime, so daring in itself, and detrimental to the interests of Commerce, only received a slight arbitrary punishment.

"An united body of Merchants and Manufacturers, whose rules are understood among themselves, have it in their power to prevent tedious and expensive litigations, the bane of harmony and industry. They have it also in their power to bring forward important questions; to apply for laws for the good of the whole, which no divided or separated interest could do with effect. They have it in their power to suggest new improvements, and to give aid to such as are worthy of pursuit; to assist the views of Parliament, in so far as they may be beneficial to the country; or to point out mistaken or partial measures that might be hurtful.

"In short, to give spirit and vigour to Commerce and Manufactures; assistance to genius and industry; to protect the just rights of individuals; to encourage the active, and discourage the idle; are objects which have a manifest tendency to render a people great, prosperous, and happy: And such are the avowed purposes of the present Institution.

"The good effects of such Societies are conspicuous in the examples of those

those Chambers of Commerce that have been already established in different parts of *Great Britain*; and it is to be hoped that similar good effects will soon result from the establishment of one in *Edinburgh*.

"But the success of every institution, however well intended, must depend, in a great measure, upon the laws that are formed for its regulation. The following rules have been approved of, for present direction; and it is to be hoped, that they will contribute to promote the interests of Trade and Manufactures in this part of the *United Kingdom*."

The Rules

As the rules, with the exception of those relating to the fees for admission (which have been commuted to an entrance-fee of five guineas), have remained ever since without material alteration, we reprint them entire.

"RULES.

"I. THAT every Merchant, Manufacturer, or Trader, residing in *Scotland*, shall have a right to become a Member of this Chamber, on his paying into the hands of the Treasurer for the time being, the sum of Two Guineas at the time of his admission, and the further sum of One Guinea annually, on the first *Monday* of *January* of every year, so long as he chooses to continue a Member. And any person paying the Chamber the sum of Ten Guineas, shall be deemed a Member of the same for life, without being subjected to any future payments.

"II. That any Member who chooses to vacate his place may do so at pleasure, on giving such intimation to the Secretary. Every Member who fails to pay his annual subscription on or before *Candlemas*, shall *ipso facto* be considered to have withdrawn.

"III. That no person so withdrawing shall ever have it in his power again to become a Member of the Chamber, or be entitled to any of the benefits of the institution; nor shall any practitioner in law, although a Merchant or Manufacturer, have it in his power to become a Member of this Chamber on any account whatever.

"IV. That the business of the Chamber shall be conducted by a Chairman, two Deputy Chairmen, and thirty Directors. The Chairman, or one of the Deputies, and twelve Directors to be a quorum.

"V. That the six senior Directors shall go out of office annually, and six others be elected in their room:—Also, the Chairman and the two Deputy Chairmen to go out of office alternately, one of them each year; the vacancies to be filled up by the Members at large, and the seniority to be determined at the first election.

"VI.

"VI. That a Secretary shall be appointed, who must be a Member of the Chamber, and whose business shall be to keep the books and papers belonging to the Chamber, to write the minutes, and to carry on correspondence.

"VII. That there shall be a Treasurer, who must likewise be a Member of the Chamber, who shall keep an account of all the moneys received and paid out by the Chamber; and he shall pay whatever money he may receive from time to time into the *Royal* Bank of *Scotland*, or such Bank or Banker as the Members shall from time to time direct, whenever the same shall amount to Fifty Pounds Sterling.

"VIII. That there shall be five Members, not in the direction, named to audit the Treasurer's accompts, three to be a quorum.

"IX. That there shall be a General Meeting of the Members held at *Edinburgh* annually, on the *Monday* preceding the Convention of the *Royal Boroughs*, for the purpose of choosing a Chairman, or Deputy Chairman, as the vacancy may happen; six Directors in room of those going out; five Auditors; a Secretary, and a Treasurer, which two last offices are to be filled up every year, and the persons holding them may either be continued or removed, as the Members shall think fit.

"X. That all elections shall be made by ballot.

"XI. That there shall be another General Meeting held on the third *Wednesday* of *January* every year, for the special purpose of reading the Minutes of the Chamber, and giving such other general directions as shall to the meeting, or to the majority, appear proper.

"XII. That any fifteen Members, not in the direction, may call a General Meeting whenever they think proper, on their giving ten days' previous notice by advertisement in the *Edinburgh* newspapers.

"XIII. That every order for money must be signed by the Chairman, or a Deputy Chairman, and three Directors, in presence of a quorum, and the same minuted by the Secretary.

"XIV. That every Member shall have a right to inspect the Minutes, by applying to the Secretary on the *Wednesday* of every week, between the hours of noon and three o'clock in the afternoon, but at no other time, unless by order of three Directors.

"XV. That all questions which come before the Chamber, shall be decided by a majority of votes; and, in case of an equality, the Chairman shall have a casting vote, besides his own.

"XVI. That the Directors shall not have it in their power to contract any debt in name of the Chamber, on any pretence whatever; but shall have it in their power to engage the funds of the Society for the purposes of its institution.

"XVII.

"XVII. That the Chairman or Deputy may call a Meeting of Directors whenever the same is thought to be necessary.—All Meetings are to be held in *Edinburgh*, in such room or hall as the Directors may appoint.

"XVIII. That an account of the proceedings of the Directors shall be printed annually, and a copy sent to every Member.

"XIX. That any additions or alterations to the present rules may be made by a General Meeting."

Royal Charter granted

These rules were subsequently embodied in a Royal Charter, which was sealed with the Great Seal of *Scotland*, 10th *July* 1786.

Mr *James Hunter Blair* was elected first Chairman of the Chamber, and Messrs *William Creech* and *James Morrison*, consented to act as Joint Secretaries. Under their vigorous management the Chamber continued to flourish; meeting for business in the *New* Church Aisle, the *Royal Exchange* Coffee House, or *Heron's* large room, *Cowgate* Inn; while the Directors maintained the *esprit de corps*, by dining annually in *Fortune's*, then the principal *Edinburgh* hotel.

Upon the building of the Merchant's Hall, the Chamber obtained for a time accommodation in it. In 1822, the property in *Hunter* Square was purchased, and continued to be occupied until the removal in 1855 to the present premises in *Melbourne* Place.

Appoints a Chaplain

In *January* 1789, the Rev. *Robert Walker*, minister of the *Canongate*, was appointed Chaplain to the Chamber; and we learn from the minutes, that, on occasion of riots in the city, which were said to be "stimulated by certain individuals who had combined under the specious pretence of seeking a Parliamentary Reform," an extraordinary meeting was held on the 18th *December* 1793, which he opened and closed with prayer. This seems to have been the only occasion on which the services of the Chaplain were in request at a business meeting;

ing; and no successor to him in the office appears to have been appointed.

From its first institution, the Chamber took an active part in all public business, attending more especially to matters of local or *Scottish* interest, and to those having reference to commerce. So early as 1793, we find a report by a committee of the Chamber upon "the new Bankrupt Act" submitted to the *Lord President*; and, in 1807, it subscribed £50, and again, in 1811, £25, towards the expense of obtaining "a new act," and throughout its whole existence, the Chamber has been unceasing in its endeavours to place the bankrupt law upon a sound footing. It is pleasant to be able to state, that this important object has been at last in a great measure accomplished by the act carried through Parliament in 1856 by Mr *Moncrieff*, then, and now again, Lord Advocate; concerning which, it has been truly said by a competent authority, that, "as regards cheapness, despatch, and efficiency in the administration of an insolvent's estate, that statute has unquestionably placed *Scotland* the foremost among commercial nations."

Adopts Free Trade principles

At an early period, the Chamber adopted the principles of Free Trade; and in the following remarkable petition, sent to Parliament on the 20th *April* 1820, relative to the then distressed state of commerce, urged, with fearless perspicacity, doctrines at that period deemed most dangerous, but which have since, to the great advantage of the community at large, become the basis of our commercial legislation:—

"*Petition of the Chamber of Commerce and Manufactures of the City of* Edinburgh, *in favour of Freedom of Trade.*

"To the Hon. House of Commons, &c.

"*This Petition Sheweth,*

"That this Chamber having been instituted by *Royal* Charter, for the express purpose of watching over the commercial interests of this part

part of the *United Kingdom*, they humbly conceive it a duty highly incumbent on them, at a period of unprecedented pressure on every branch of mercantile industry, most respectfully to call the attention of the House to the depressed state of foreign commerce, and to offer their opinion of the causes that in a great measure contribute to this depression; whereby the general industry of the kingdom is checked, its manufactures consequently deeply injured, and its revenue in danger of being soon most seriously diminished.

"It appears to your Petitioners that the system so long persevered in, of laying on heavy duties on imports from foreign countries, tends directly to lessen the demand in those countries for the produce of the industry of our own nation.

"That the doctrine maintained by many Statesmen, that in order to accumulate wealth by trade, a nation must export more than it imports, is most erroneous.

"That upon this erroneous doctrine is founded the present commercial policy of this country.

"It appears to your Petitioners that the profits derived from the exportation of the produce of our manufactures, agriculture, fisheries, and mines, can in no other shape be realised, or made effective to the increase of the national wealth, but in the form of imports.

"That it appears to your Petitioners that the sure way to increase foreign commerce is to encourage the industry of other nations with whom we trade; or, in other words, to enable them to become our customers.

"That, to that end, we should admit on low duties the raw produce of other countries, and such articles of commerce as we are precluded from producing, by climate or other circumstances.

"That your Petitioners consider that the high duties on *Baltic* wood and iron, on wines, and more particularly on *French* wines, on raw silk, and on many other articles of trade, the produce of foreign countries, have directly and indirectly lessened the demand in those countries for the productions of this realm; for by checking the industry of those foreign nations, we disable them from being our customers, and we hold out an example to their Governments to lay on heavy duties on the manufactures and other exports from this country.

"That it appears to your Petitioners that this system of restrictive commerce has been followed since the Peace, by the Government of almost every nation with which we trade, in strict conformity with the system adopted by *Great Britain*.

"That whatever may be the perseverance of other nations in this system, the *British* Government should begin a more liberal and wise commercial

mercial policy, without regard to reciprocity of benefit between us and any particular nation; because, by encouraging an increased import from one nation, we are certain of gaining an increased export directly to that nation, or, intermediately, to some other nation.

"That it appears to your Petitioners that such a liberal system of commercial policy, which is thus humbly submitted to the consideration of the Honourable House, would produce a greater revenue, from the increased quantity of imports, although subject only to low rates of duties; and at the same time would promote national industry, as a consequence of a proportional increase of exports.

"May it therefore please your Honourable House to permit this Petition to be taken into the consideration of a Committee of the House, and to adopt such measures as, in the wisdom of your Honourable House, may be deemed most prudent and efficacious;

"And your Petitioners will ever pray.

"*Signed in the name, and on behalf of the Chamber of Commerce and Manufactures of the City of* Edinburgh, *and the Seal of the Corporation affixed thereto, the* 20*th day of* April, *in the year* 1820.

(Signed) "ALEX. HENDERSON, Chairman."

The Chamber evinces an illiberal spirit

It is not, however, to be expected or supposed, that all the proceedings of the Chamber, in the earlier period of its existence, were dictated by an enlightened political economy. In 1786, we find the Chamber sending information to the Commissioners of Customs, that several workmen, belonging to the *Carron* Company, had been discovered on board a ship bound for *Russia*, and had been brought ashore by a justice-of-peace warrant; and again, in 1787, we find that, in consequence of a memorial from Mr *Crichton*, informing the Chamber "that one of his journeymen coachmakers, had been enticed to go off to the *United States* of *America*, and had taken with him his tool-chest," (said tool-chest being the workman's own,) it was agreed "that Mr *Crichton* should have the countenance and aid of the Chamber;" and a committee was appointed to inquire what steps were necessary. What Mr *Crichton* wished the Chamber to do remains, however, still a mystery.

To

To realize fully the injustice of these interferences with the right of workmen to sell their labour to the best advantage, it is necessary to keep in view that these proceedings took place during a period of profound peace, and that in neither case was any breach of engagement alleged as authorizing the harsh steps taken or proposed.

The Chamber is recognised by His Majesty

A little later, we find the members of the Chamber exercising their influence much more beneficially. On the 24th *February* 1798, they adopted a petition to His *Majesty*, representing the case of a cargo of flax, &c., shipped for *Leith* and *Bo'ness* on board a *Prussian* vessel, being captured and carried into *Shields*, and prayed that it might be allowed to proceed on its voyage, as its detention would be greatly detrimental to the agriculture and manufactures of the country.

This petition led to a long correspondence, the result of which was a communication from the *Lords* of the *Privy Council*, intimating that " His *Majesty* had come to a resolution of granting licenses to his subjects for the importation of flax and flax seeds, garden and grass seeds, barilla, madder, and other dyeing stuffs, and other articles of indispensable use from certain countries at war with His *Majesty*. But as their Lordships are of opinion that an indulgence of this nature should be limited to persons who may safely be trusted with it, their Lordships will not think it proper to advise His *Majesty* to grant any such licenses to any merchants, or other persons residing in *Scotland*, but such as shall produce recommendations from the Chamber of Commerce of *Edinburgh*, upon whose earnest application His *Majesty* has been pleased to consent that such licenses shall be granted; as the members of that Chamber must be best acquainted with the character of the persons who may so apply; and their Lordships are persuaded

persuaded that the Chamber of Commerce will make a discreet use of the confidence thus placed in them."

From the minutes, we find that the recommendation of the Chamber was in considerable request by manufacturers in *Aberdeen* and *Arbroath*; and that, in *June* 1803, on renewed hostilities with *Holland*, application was again made to the *Privy Council*, in consequence of which, "licenses, similar to those in use during the former war, were agreed to be granted."

The Chamber assumes the functions of a *Tribunal of Commerce*

At an early period, the Chamber adopted regulations for the settlement of cases referred to the arbitration of the Chamber, and we find that, accordingly, it fulfilled the office of a *Tribunal of Commerce* in several important submissions, the earliest of which was in 1792, and the latest in 1820. Few particulars, however, regarding these submissions are recorded, as, in accordance with the rules under which they were accepted, no part of the proceedings was to be minuted, but the application, with the names of the referees, and the decreet.

The Secretaries

Mr *Creech* continued to perform the duties of Secretary for many years, and in 1806 was succeeded by Mr *Steuart*, the original founder of the Chamber, who first singly, and then in conjunction with the late Mr *Alexander Wight*, banker, held the office till his death in 1824. Mr *Wight* remained sole Secretary for above ten years, resigning in 1834, shortly after which he removed to *Bradford*, and afterwards to *London*.

In 1835, the present Honorary Chairman, Mr *Macfarlan*, was elected to the vacant office, and in the same year the entry-money was reduced from ten to five guineas. Mr *Macfarlan's* services to the Chamber and to the public, during the many years in which he performed the duties of Secretary, are well known to the members, and need not, therefore, be detailed; it

it may be enough here to state that when he was elected, the Chamber consisted of 74 members, and, before his retirement, numbered above 240; and that, within the same period, its influence and usefulness had proportionately increased.

The present functions of the Chamber

The Chamber now consists of upwards of 300 members, comprising a large portion of the bankers, merchants, and manufacturers of *Edinburgh*, *Leith*, and neighbourhood. Since its origin, the Chamber has been employed in promoting freedom of commerce, and in opening the markets of the world to manufacturing and commercial enterprise. Much of its attention has been devoted to the improvement of commercial law, in which, although many important ameliorations have been effected, much still remains to be done, to bring our laws and their administration into harmony with the necessities and spirit of the age.

The Chamber likewise occupies an important position as the recognised representative of the mercantile community of the *Scottish* metropolis and its vicinity, in all intercourse either with the Government or with the representatives of commerce in other large cities.

The recent acquisition of more extended accommodation, and the desire to give to the members of the Chamber an additional interest in its proceedings, have induced the Directors to hold occasional evening meetings, which may have less of a formal or business character than the regular ones, and at which lectures may be delivered, and information communicated, on subjects connected with commerce or commercial law, which may be beneficially accompanied by social intercourse and mutual interchange of opinion.

The Directors considered themselves fortunate in having induced Mr Sheriff *Hallard* to inaugurate these meetings by his

his very able lecture on Judicial Remedies, a subject second in social importance to none, and one to which the Chamber has given great and unceasing attention.

Professor *Piazzi Smyth's* lecture having as its object the attainment of exact observations at sea, and the saving thereby of life and property, and bringing, for the first time, prominently before the public an important mechanical invention, which, when perfected, promises to be invaluable to navigation, was listened to with the deepest attention by an audience, which included many of those most distinguished among our citizens in science and art, and will doubtless be now read with equal interest.

In the coming season, without interfering with the ordinary duties of the Chamber, it will be the object of the Directors at these meetings to call the attention of the members to subjects of similar importance, and to bring together the various classes which form the society of the *Scottish* metropolis: thus adding an additional feature of interest to the numerous attractions of the city.

EDINBURGH, *June* 1859.

A List

A List of the Chairmen of the Edinburgh Chamber of Commerce from its Institution to the present time.

Year.	
1786.	Sir James Hunter Blair
„	Thomas Elder, Lord Provost
1787.	David Steuart, Banker
1788.	Sir William Forbes of Pitsligo
1789.	Sir James Stirling
1790.	David Steuart
1791.	William Ramsay of Barnton
1792.	Sir James Stirling, Lord Provost
1793.	Sir William Forbes
1794.	Thomas Elder, Lord Provost
1795.	Robert Young
1796.	Neil M'Vicar
1797.	Sir William Forbes
1798.	Sir William Forbes
1799.	William Ramsay
1800.	Sir William Forbes
1801.	Sir James Stirling
1802.	Sir William Forbes
1803.	Neil M'Vicar, Lord Provost
1804.	Sir William Forbes
1805.	John Balfour of Pilrig
1806.	Neil M'Vicar
1807.	John Balfour
1808.	Thomas Williamson
1809.	William Ramsay
1810.	Thomas Williamson
1811.	Sir William Forbes
1812.	Sir John Hay of Hayston
1813.	Thomas Williamson
1814.	Sir William Forbes
1815.	Sir William Forbes
1816.	Alexander Henderson
1817.	Thomas Allan
1818.	Ebenezer Gilchrist
1819.	Alexander Henderson
1820.	John Pitcairn
1821.	John Wardrop
1822.	Gilbert Laing Meason
1823.	Thomas Allan
1824.	Walter Brown
1825.	William Trotter, Lord Provost
1826.	Alexander Henderson
1827.	Charles Baxter
1828.	John Lauder
1829.	William Allan
1830.	James Mackay
1831.	William Braidwood
1832.	Alexander Clapperton
1833.	Robert Scott
1834.	Adam Black
1835.	John Wigham, jun.
1836.	James Hill
1837.	Alexander Jamieson
1838.	John Craig
1839.	Duncan Cowan
1840.	Sir James Spittal
1841.	Robert Scott
1842.	Archibald Thomson
1843.	Thomas Sawers
1844.	Robert Cadell
1845.	Alexander Clapperton
1846.	Samuel Aitken
1847.	William Galloway
1848.	John Macfie
1849.	John Ritchie
1850.	John Ritchie
1851.	Charles Cowan, M.P.
1852.	G. A. M'Laren
1853.	John F. Macfarlan
1854.	John F. Macfarlan
1855.	John Clark
1856.	George E. Russell
1857.	William Law
1858.	Chas. Lawson of Borthwick Hall
1859.	Robert Mackay Smith

¶ *Here follows Report of a Conversazione, held on the 24th* February 1859, *for the purpose of hearing the Lecture of* Sheriff Hallard *on* Judicial Remedies; *and, of another, held on the 26th* April 1859, *to hear* Professor Piazzi Smyth's *Lecture on the* Present State of the Longitude Question in Navigation.

I.—*REPORT of a* Conversazione *held by the* Edinburgh *Chamber of Commerce, in their Hall, on* Monday, 24*th* February 1859.

Mr R. M. Smith having taken the chair, upon the motion of Mr *Macfarlan*, read the following letter from Mr *Lawson*, dated *Paris*, 21st *February* 1859, and addressed to the Secretary:— Mr *R. M. Smith*

"My Dear Sir.—I am extremely sorry to say, that the state of my health so imperatively requires rest, that I cannot be present at Sheriff *Hallard*'s Inaugural Lecture, at the *Chamber of Commerce*, on the 24th current, to thank the Sheriff personally, for so kindly, and, I am quite sure, most ably, entertaining and instructing us with a Lecture on so popular and useful a subject.

"This inevitable absence from one of the most pleasing duties of my office of Chairman annoys me very much, and I feel that I shall consequently lose a treat of no ordinary kind.

"You know that I have taken a warm interest in the arrangement for establishing this new system of occasional Lectures, in connexion with our Chamber. Commercial men, as a body, must take the same steps for enlarging their knowledge, that have been long and successfully adopted by the followers of Art and Science, Literature, Agriculture, and other pursuits, in which those not entirely engaged in the trade of making money take an interest.

"Commercial

Mr *Lawson's* Letter

" Commercial men must meet in their hours of leisure, not only for social purposes (meetings which, by the bye, are not to be despised), but for the purpose of intercommunicating knowledge, and taking advantage of the special acquirements of their friends and fellow citizens, in all branches bearing upon their business pursuits.

" I have always thought, though the first business of a man who has his own living to earn, is zealously to pursue that calling, still, he is not to content himself with just handling the articles of his business, valuing them according to the *Price Current*, and setting down his profit and loss upon them, without seeking to know how they were produced, whence they came, where they go, and their various uses. There is a history, and a certain knowledge, attached to the merchandise of every business, which must be fully learnt, before we can satisfactorily make progress; and the studies of these are not only pleasant, they not only help to occupy the mind in hours of leisure, but they are usually, in the long run, profitable.

" I have now been nearly fifty years engaged in business, and at my age, and when on the point of retiring from active commercial occupations, I may be permitted, without being accused of egotism, to say, that I attribute a large measure of my success, and certainly a great share of the happiness of my life, to the attention I have paid to the scientific part of my business. And, I am sure, that the prosperity of our Chamber, and its usefulness, cannot fail to be increased, by encouraging, in every way, attention to the study of all those branches that bear on the particular pursuits of its members.

" The foundation of this study being laid, there is something mightily pleasing and persuasive in the voice of a man speaking on a subject of which he is perfctely master; and I rejoice that Sheriff *Hallard* has so kindly consented to make the commencement.

" The subject of his Lecture is one that comes home to every one engaged in trade, and should interest every individual, directly or indirectly, connected with the commerce of the country, viz., ' Judicial Remedies,' for, if I mistake not, it will suggest remedies for the present cumbersome, and scarcely efficient, system we have for obtaining adjudication on the multitudinous questions which arise in business, and which, though beyond the Sheriff's jurisdiction, are not quite extensive enough to justify a suit in the Court of Session.

" I venture to say, every trader or merchant in *Scotland*, feels this to be a serious obstacle in the way of satisfactorily carrying on his business; and any plan which could efficiently remedy this evil, would, I am sure, be hailed by one and all as a most beneficial and useful piece of reform.

" By

Mr *Lawson's* Letter

"By a rule, in my opinion a very judicious rule, Lawyers are excluded from membership of the Chamber. We have, therefore, the more reason to be satisfied with the arrangement, which gives us the advantage of a Lecture on so important a subject, and to be grateful to Sheriff *Hallard* for his kindness in devoting his talents to enlighten and instruct us.

"I beg you will do me the favour to express my thanks to the Sheriff for this kindness, in giving us his services in so useful and entertaining a manner, and at the same time to assure him how much I regret being kept from my post on *Thursday* evening.—I am, my dear Sir, very faithfully yours, CHARLES LAWSON."

Mr *R. M. Smith* continues his address

You will regret with me the indisposition of our much esteemed Chairman, which prevents his taking his place here; and I am sure you will cordially join me in the hope, that we shall soon see him again in renewed health and strength, to enable him to do further good service to the Chamber and to the community at large. As we are honoured this evening with the presence of many gentlemen to whom the constitution of this Chamber, its business, and objects may not be altogether known, I would willingly have given a sketch from the Records of its proceedings, in which there is much both interesting and instructive; but the subject is too wide and of too much value to be treated in a cursory manner, and well deserves a separate evening from more able hands, such as those of our friend Mr *Chambers*. Our Chairman's letter is so comprehensive that it is unnecessary to enlarge upon it. The amendment of the Law has ever offered so fertile a field to this Chamber, that no apology need be offered for the introduction of the subject for this evening. My friend Mr *Lawson* refers to the exclusion, by our Charter, of Lawyers from the Chamber. The minute is as follows: date 21st *December* 1785:—

"Nor shall any practitioner in law, although a merchant or manufacturer, have it in his power to become a member of this Chamber on any account whatever."

I find no explanation of this curious resolution. Probably the legal practitioners of those days may have been opposed to any amendment of the Law. Lord *Brougham* recently declared, that, in the reforms of Mercantile

Mr *R. M. Smith*

Mercantile Law, he has ever been opposed by the *English* lawyers. Fortunately, in *Scotland*, we have no such complaint to make: on the contrary, it is by the aid of our *Scottish* lawyers that so much progress has been made; and it is to them that we confidently look for much that has still to be gained in that direction. To the profession in *Edinburgh*, the Chamber has been under continued obligations, more particularly to Mr *William Alexander*, whose name could not be omitted here when speaking on the subject. The Chamber, in 1786, appears to have had no great liking for the Parliament House, if we may judge from the following minute under date of 6th *September*:

"A memorial was presented from Messrs *David Knox* and *J. Stoddart*, praying that the Chamber would appoint them an annual salary for such members of the Chamber as should attend the Court. It was resolved, unanimously, that a salary to the memorialists cannot at present be granted, it being the intention of the Chamber to keep as much out of the Parliament House as possible."

But I must not detain you. Mr Sheriff *Hallard* having kindly responded to the request of the Directors, to address you, I have now the pleasure of introducing him.

Mr Sheriff Hallard then delivered an address on "Judicial Remedies," which was listened to with great attention. At the close of the address,

Mr *Duncan M'Laren*

Mr Duncan M'Laren said, he had been requested to perform the agreeable duty of moving, that the thanks of the meeting be given to the learned Sheriff for his able and interesting Lecture on Law Reform; and although the opinions expressed by him, on some important points, were opposed to the opinions which had been expressed by the Chamber as a public body, and, no doubt, to the opinions of many here present, they were not the less indebted to the learned Sheriff on that account; because it was only by having the opposing views of different parties publicly stated and candidly discussed, that we could hope to carry any measure of legal reform; and there would be ample opportunities hereafter for the Chamber to discuss the various questions which had been raised in the able and interesting Lecture with which they had been favoured.

Mr

Mr Robert Chambers had much pleasure in seconding the motion, not that he could at once say whether he entirely approved of the learned Sheriff's views; their merits were for deliberate discussion afterwards; but he cordially admired the absence of all dogmatism from the way he presented them; and he thought the learned gentleman had fairly won their gratitude even by the act of coming amongst them as he had done. There was great use in class meeting class. It engendered the Christian good feelings which ought to prevail among all men, and it had an instructive effect. We were all the better of seeing our reflection occasionally in the faces and minds of other men. Mr *Robert Chambers*

Mr Sheriff Hallard having replied,

Bailie Blackadder moved a cordial vote of thanks to Mr *Smith* for his conduct in the chair; after which the proceedings terminated.

II.—*REPORT of* Conversazione *held by the* Edinburgh *Chamber of Commerce, in their Hall, on* Tuesday, *26th* April 1859.

Mr R. M. Smith, the Chairman of the Chamber, moved that Mr *Lawson* take the chair.

Mr Lawson said that, before introducing Professor *Smyth*, he must explain how he came to be in the chair to-night, as it might otherwise bear the appearance of usurpation, seeing that he was not now Chairman of the Chamber. He wished to explain, therefore, that when Mr *Smith* took the chair for him at Sheriff *Hallard's* Lecture, during his absence in *February* last, it was then agreed that he should have that honour the next opportunity that occurred; and he assured them it was an honour he had no wish to waive. He considered these lectures, which Sheriff Mr *Lawson*

Mr *Lawson*

Sheriff *Hallard* had so ably inaugurated, and which he was sure Professor *Smyth* would warmly second, to be of the highest benefit to the Chamber. They treated on subjects of modern importance, and came to them direct from the very men who were so well able to enlighten them. The subject for to-night was not only a scientific, but a most useful and eminently philanthropic one; and, from what he already knew of it, led him to infer that a further consideration of it might possibly lead to the discovery of what had so long baffled the researches of so many eminent men. The problem, towards a solution of which Professor *Smyth* had so long devoted himself, was now, he thought, in a fair way of being solved; and, when that time arrived, he hoped the learned Professor's name would appear in the post of honour. For what he had already done, and was now doing, he was sure he well deserved, and would obtain, the hearty thanks of many more than this Chamber.

Professor Smyth then delivered the Lecture, "On the present state of the Longitude Question in Navigation."

Mr *J. F. Macfarlan*

Mr J. F. Macfarlan at the close of the lecture, moved the thanks of the meeting to the learned Professor; and, in doing so, expressed the pleasure which he had himself experienced during the delivery of the lecture; a lecture which had kept them entranced for a period of nearly two hours, so as to be almost entirely unconscious of the time which it had occupied; a lecture which, from the clearness of its statements, the perspicuity of its language, and the aptness of its illustrations, commended itself to every one, so as to induce a belief that they actually understood it; while the profound nature of the subject made that a task even for the learned. The Chamber was highly favoured, indeed, in obtaining the services of so distinguished a man on the present occasion, and, doubtless, would most cordially concur in voting him their unanimous thanks.

Professor *Kelland*

Professor Kelland said that, in consequence of the lateness of the hour, he must content himself with simply seconding the motion of Mr *Macfarlan*, which, however, he did with the greatest pleasure.

Professor

Professor Smyth, in acknowledging the compliment, proposed a vote of thanks to Mr *Lawson*.

Mr *Lawson*

Mr Lawson moved a vote of thanks to Mr *R. M. Smith*, the President, and Mr *Harrison*, the Secretary, and said, that he had heard in his day many lectures, but he had seldom the good fortune to have heard one from which he had derived so much instruction on what was popularly considered rather an abstruse subject to the uninitiated. It was a great characteristic of a good lecturer to make himself intelligible to the most ordinary capacities; and Professor *Smyth* had not only done this, but, judging from the audience, had, at the same time, made his lecture captivating to the scientific and more learned. For all the arrangements connected with the enjoyment of this delightful evening, they were indebted to Mr *R. M. Smith* and Mr *Harrison*, the able and energetic Chairman and Secretary, to whom he now moved a vote of thanks.

This vote was carried by acclamation.

After the lecture, many of the gentlemen present had an opportunity of examining the mechanism of the Professor's ingenious instrument, with which one and all expressed themselves highly delighted.

OFFICE-BEARERS OF THE CHAMBER

FOR 1859-60.

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On the Present State of the Longitude Question in Navigation.

IN attempting this evening, Mr President and Members of the *Edinburgh* Chamber of Commerce, to set before you in a practical manner some special features in the important subject of *Naval Longitude*, it is not impossible that I may be met by the objection—that there can hardly be any great necessity for such a discourse in this city of ours, when its good port of *Leith*, though enjoying in the Firth of *Forth* the most spacious

Possible objections to the locality chosen for the discussion

Natural characteristics of a port in the Firth of *Forth*

spacious entry of any haven in the world, yet looks out only on confined waters like those of the *North* Sea. There can be no doubt, too, that in such a situation, the chief commercial intercourse should be carried on, even as it is, with the neighbouring coasts of *Germany* and *Norway*; while the nautical proceedings consequent thereon, may usually be prosecuted by a very simple style of navigation, wherein no man could well pretend, that celestial determination of longitude must be considered the first and foremost and most constantly needful point to be attended to.

Any one, however, even of the general public, who has paid but very small attention to the progress of *Edinburgh* and *Leith* during late years, can hardly fail to have perceived the undoubted extension which has taken, and is still taking, place in the commercial relations of both cities; for a single walk now, at

at any season of the year, down to those docks, which have themselves been recently so much enlarged and improved, will shew to the most casual gazer, over and above the ordinary vessels of the *North* Sea trade, many a fine ship or gallant barque just arrived from, or loading for, *Australia* or *New Zealand*, *Callao* or *Hong Kong;* and not a few of these vessels he will perceive are owned, and have been built, here; shewing that the local shipping interest in all its branches is fast increasing, and chiefly by those inaudible and unadvertised steps, which so surely prove in the commercial world, that a profitable line of employment has been opened up and is being successfully followed out.

Objections answered

Ocean trade of *Leith* rapidly increasing

Whatever, then, may have been the general rule and practice hitherto, real ocean-going ships are now an important section of the sails on the Firth of *Forth;* and in a short time after

Longitude important on all ocean voyages

after such vessels have left our rocky shores behind them; they launch forth upon the true blue, and, so to speak, fathomless, yet current-vexed, waters of the great *Atlantic;* and compete there for nothing less than the commerce of the whole world, with all other ports and mercantile communities. Then, consequently, to men of *Leith*, as to others, comes the scientific question of Longitude, in all its force and with all its urgent necessity; as imperatively too now, as it ever did to any of the seamen of a past age, when the subject occupied, it must be confessed, a much larger share of public attention, not only in this, but in every, country of the civilized world: for there was a time when every one was talking about it; when all able men were taxing the powers of their brain in its investigation; and when each enthusiastic young mother, at least within the influence of Navigation and the schools, would

would dote over the cleverness of her little son as something so extraordinary, that she felt sure when he grew up to be a man, he would infallibly "discover the Longitude."

Notwithstanding, however, that the popularity of this subject has waned, yet the importance of Longitude, being attended to by all ocean-going ships, not only daily, but even hourly, is, at the present moment, more weighty than ever; and if we do not hear so much about it as formerly, the reason is simply, that it is now better known and understood; and from having once been a mystery, which only the more learned were competent to dispute upon, it has at last come to form part of the regular work, morning and evening, of every captain and mate afloat.

Not so popular a topic as in olden times, but quite as essential to be attended to in practice

This remarkable perennial quality in the importance of Astronomical Longitude to ships at sea, arises mainly from the circumstance, that all

all vessels—no matter whether we take a little barque, such as one of those which conveyed the Pilgrim Fathers to the *American* plantations, or the finest modern liner of clipper build and 3000 tons burthen, or the most splendid steamship, screw or paddle, and it signifies not whether there be one, or two, or any number of them together—they are all equally drifted along at the mercy of ocean currents, which, whether from the *Polar* or *Equatorial* regions, render erroneous, and even utterly nugatory, every other method but the astronomical, for determining a ship's place with accuracy; and it is often, therefore, only by such celestial observation that the proximity of dangerous rocks can be certainly known and avoided.

Why Longitude, as derived from astronomical observation, is so important on long voyages

From this statement, it must, nevertheless, appear, that what is popularly understood as, the Longitude at sea, is more strictly, *the place of a ship at sea as determined by astronomical observation*,

vation, in contradistinction to determination from dead reckoning, or observation of terrestrial objects of any kind; and therefore, includes Latitude as well as Longitude. It does so; but the former operation is so very much more simple than the latter, and may so surely be expected to have been already accomplished, whenever the latter has been even approximately arrived at; that the instinct, as it were, of all men, has long since led them to speak of the whole case, under the name of its more difficult component; and in that way to keep up prominently before successive generations, the main obstacle towards whose reduction and final removal, their efforts should ever be concentrated.

Full meaning of the term *Longitude*, as used in Navigation

The extraordinary amount of such exertions which our ancestors had to make, is very difficult for us now to appreciate fully, when the results of their discoveries and researches have long

Its rise and progress

long since become household truths and facts among us; but some effort to realise the situation in which they found themselves, is essential to enable us both to perceive clearly their place in history, and to understand all our own duty and responsibilities.

The earliest notable successes in Naval Longitude

Neither have we to go back very far to get at something like the infancy of practical Longitude knowledge; for referring to no longer ago than the days of *Columbus* (A. D. 1492), we plainly there arrive at a time when, however well the abstract principle of Longitude was perceived,—and it must have been felt with glorious fervour, seeing it led that great man over all opposing obstacles to his immortal discovery of *America*,—the method of applying it in practical measurement was yet incorrect and inefficient to an astonishing degree. So much, for instance, was *Columbus* thrown out by the error of his best observations and calculations,

culations, that he believed to his dying day, that the *Antilles* and *Caribbean* Sea were nearly in the same Longitude as *Hindostan;* and that he had thus easily and quickly reached the *East Indies*, by sailing to the west; or that by traversing a certain number of measured miles, he had gone nearly three-fourths round the entire globe, instead of less than only one-fourth. No wonder he remarked to the intellectual Queen *Isabella*, his admirable patroness, "The earth is not very large;" but what untold miseries did he prepare for the first navigators, who afterwards directed their adventurous course so confidently westward, from the western coast of *America;* and found, instead of a mere strait, the whole broad *Pacific* with one hundred and ninety degrees of Longitude, between them and *India*.

Columbus and the Western world

These practical errors, however, notwithstanding, the time of *Columbus* was a noble one

The first age of the Longitude question closes

one in the history of Naval Longitude: The whole subject received from him an immense impulse and development; men's minds, from dwelling only on the wonders of the *South*, were directed to the more extensive mysteries of the *West;* new worlds, *i. e.*, continents, were discovered; grave doubts, which had long agitated society, were solved at once and for ever; and succeeding races of men commenced their career with immense advantages over their predecessors. With the death of *Columbus* therefore (A. D. 1506), ends our first age, the heroic age, of the Longitude question at sea.

The second age of the Naval Longitude question commences hopefully

Scarcely had that age closed, than the second was conspicuously inaugurated, by many first-rate academical men taking up the more scientific part of Navigation; and endeavouring to furnish the adventurous sailors, their contemporaries, with, above all other things, a good method

method for finding Astronomical Longitude at sea; for that was the part of the seaman's quiver which was more deficient than any other. Accordingly, the literature of that distant period soon began to teem with learned treatises on Nautical Astronomy; and times that we are inclined to look back upon as almost belonging to the dark ages, produced the writings of *John Werner* in 1514, *Peter Apian* in 1524, *Gemma Frisius* in 1550, *Pedro Nunez* in 1560, and many others; wherein we find, though not in a form or condition in which they could be immediately employed, the original suggestions of various Longitude methods since perfected and now in daily use.

Authors of the Period on the Longitude

Not only, too, were the philosophers of that epoch deeply impressed with the dangers continually incurred by sailors in their inability to determine the Longitude; but every enlightened government, particularly of maritime communities

munities, gradually became convinced, and acted energetically on the conviction, of the importance "of encouraging to the utmost effort of human ingenuity, whatever could be employed for improving this defective state of navigation." And hence it was, that, in 1598, *Philip* III. of *Spain*, offered 100,000 crowns, and soon after, the States of *Holland*, 30,000 florins, to whoever should succeed in devising a practical solution of the problem.

The Governments of *Spain* and *Holland* act zealously in the cause

Amongst the many who strove in what was then so conspicuously the cause of philosophy and progress, the renowned *Galileo Galilei* (A. D. 1610), brought the greatest accession of material help, derived, too, mostly from his own instrumental inventions and astronomical discoveries. He directed his chief exertions to the following part of the problem:

Galileo's services

The thing desired, was, to enable a sailor to ascertain the Longitude of his ship in any part

part of the world from celestial observation. Now, what else is such Longitude, than merely the difference at any instant between the local time at the ship, and the local time at some other place whose meridian has been taken as the line of departure. It *is* this; and the *local* time at either place is something quite easy of ascertainment by the respective observers, say, through means of the sun coming to the meridian, or his rising or setting, or his reaching a definite altitude. In that part of the matter, therefore, there was no difficulty, no more at least than in determining the latitude by the usual observation. But then, the local times having been severally obtained, say one in *America* and the other in *Europe*, the distant navigator required to be able to compare them together, and to contrast instantaneously his result, with that procured in the old country thousands of miles off, at the same moment.

Wherein he assisted

Longitude obtained at sea by comparison of the local times of two separate places

To

To make such a comparison actually and directly, was of course impossible without something of the nature of an electric-telegraph communication, which was not then in existence; but *Galileo* proceeded with eminent skill in this manner: His recent invention of the telescope had proved the planet *Jupiter* to be encircled by four satellites; and these, in their quick revolutions around him, were so regularly eclipsed, that they might be made to serve, he soon found, as a species of clock-signal, equally visible, on account of its celestial position, to all parts of the earth; and capable, happily, of being calculated with some accuracy beforehand, in terms of the time of any known meridian. Hence, did sailors on a distant voyage desire to know their Longitude; they merely had to note the instant of their *local* time, at which one of the *Jovian* satellites was eclipsed, and comparing that with *Galileo's* computed

Prediction by calculation, conjoined with a special observation, made to supply one of the local times

Mode of employing the eclipses of *Jupiter's* satellites in the above case

computed *European* time of the same event, they obtained their object at once.

Nothing could well be simpler; and in first principles, this method did indeed appear to be nearly everything that could be desired; but in practice, how many troubles started up; the most immediate and intolerable of them all being, perhaps, that when *Galileo's* telescopes were sent on board ship, and any rolling motion began, not the most skilful seaman there could hold the telescope so as to keep the planet in view. This was soon fatal to the method ever being actually used at sea; and even on land the drawback was experienced, that, for a considerable part of the year, *Jupiter* was so near the *Sun*, that the glare of daylight prevented the satellites being seen; while finally, and worst of all, the phenomenon not being an instantaneous one, but depending on the gradual covering or uncovering of a disc of sensible size, would be

Practical difficulties in observing them

be seen at a different moment of time by every different eye, every different telescope, and under every different degree of transparency of the atmosphere, or altitude of the planet.

These latter are, unhappily, quite fatal objections to *Galileo's* scheme, and no improvements of science can remove them; so, although the theory of *Jupiter's* satellites has been wonderfully perfected of late years, and though the *Greenwich* times of their eclipse-phenomena, for every day of the year, are now regularly predicted for several years beforehand in that wonderful book of astronomical prophecy, the *Nautical Almanack*, no use is made, or attempted to be made, of them in ordinary navigation.

Failure of the satellites' method; solar and lunar eclipses, &c.

In fact, they, the satellites, were a failure for the purposes of Naval Longitude. Many other suggestions of the time also failed when tried in practice; and the general result was not

not re-assuring. Great men had appeared, ingenious ideas had been produced, and intense expectations had been aroused; but where were they all when they came to be measured against the majesty of Nature, as displayed in the orbs of heaven, or viewed on the world of waters? Nowhere!

Unsuccessful close of the second age of the Longitude question

Amongst sailors, therefore, this second age in the history of the Longitude question formed rather a hopeless period, stretching from the beginning of the sixteenth, far into the eighteenth, century; and appeared even doubly gloomy to them, by contrast with the brilliant spectacle of the regeneration of science and learning, that was simultaneously taking place on shore. There, Physical Astronomy shone like the new rising sun; but on shipboard, poor Nautical Astronomy was sunk in all the barbaric rudeness of the middle ages, with "dead reckoning" for its only Longitude method

method; and one so utterly untrustworthy, that an error of several degrees used to be the ordinary result of a voyage of only two or three weeks duration.

The third age begins

The living light, however, which had just burst on the learned of mankind with the publication of the *Novum Organum*, and very shortly began to bear such brilliant fruits, as are vouched for by the *theory of gravitation*, and the invention of the steam-engine, was destined to be the prelude of discoveries that marked a *third* age in the Longitude question at sea.

A new nation takes a prominent position in the Longitude question

With this age the eighteenth century had opened, and a new nation appeared on the scene. A nation of sufficient originality, and of striking obstinacy; of eminent mechanical ability, but most perverse habit of questioning and trying everything, and of being excessively discontented

discontented, until something practically satisfactory had been arrived at.

This nation, gentlemen, was the *British* nation!

We did not, we must confess, appear very early in the fray; and were even then only to be driven into it by facts and figures frequently repeated. First, the scientific men began to disquiet themselves about a something that evidently ought to be accomplished for the safety of Navigation; and then, the commercial world moved; and finally, after a great deal of appeal, the heads of Government condescended to take steps in the matter; and though at first, as it is believed on traditional policy, inclined to do as little as possible, yet they were gradually urged into something like effective movement, when pressed with the continued spectacle of wrecks upon wrecks in the Royal as well as the Merchant Navy.

Characteristics of this, *British*, nation

Calamities

Calamities, touching which, the following is an example of the manner in which they at length began to be viewed by all men, as handed down to us in the tenth article of a statement made to Parliament in 1714, running thus:—"Because it [the discovery of a good method for finding the Longitude of a ship at sea] will save the nation great sums of money, which the want of it does now occasion; and because it will prevent the loss of abundance of ships and lives of men; as it would certainly have saved all Sir *Cloudesley Shovel's* fleet had it then been put in practice."

Board of Longitude appointed

Accordingly, in that same year, an Act was passed appointing a Board of Commissioners for promoting and advancing the question of Longitude at sea; and holding out, in imitation of the Kings of *Spain* and *Holland*, large pecuniary rewards to stimulate inventors.

No doubt inventors were stimulated by such offers;

offers; but nations, as well as ministers, require to be told, that it is not in the power of mere money, or legislation, to have scientific discoveries made to order whenever they are wanted; and our Government found it to be so in this case to their grievous cost, for no perceptible results were produced for more than a quarter of a century. *Great Britain*, however, had now fairly entered the field, her sons were at work, and their's are the next successes which the historian of Longitude at sea has to chronicle.

Invention does not come of command or money, alone

The first of these steps was of a purely instrumental character; and was the invention, in 1740, of an important but simple arrangement, whereby the effect of the heaving of a ship's deck was prevented from interfering with the accuracy of angular measurement. The usual plan of making an observation, excepting a method based on the principle of luminous images,

Improvement in angular instruments

images, and not of general application, had been to look with the measuring instrument at one of the two objects to be observed, *direct*; and at the other as *reflected* from a moveable mirror, by whose inclination the second might be brought to be seen in the same line as the first object; accompanied, however, by this monstrous practical objection, that with every heave of the ship, the direct object went out of the field one way, and the reflected the other, by the full amount of the whole angular movement of the deck on which the observer was standing.

Hadley's sextant

In this state of the case, Mr *Hadley* came forward and shewed, that if, in place of viewing the second object by *one* reflection, it were viewed after *two* reflections, the rolling of the ship will then act upon it, in a precisely similar manner to that in which it acts on the direct image of the other object; and that, consequently, so long as the two objects appear in the

the field at all, they will be seen at exactly the same *relative* distance apart; enabling, therefore, this distance, the really important feature, to be measured in such an apparatus with nearly as much accuracy on sea as on land.

Its principle, and practical success

The principle was thus happily simple, and its action was found in practice to be what might be called perfect; for no violence in the motion of the ship could disturb it; and all the skill that was required from the sailor's hand during observation, was merely to hold the instrument by so much steadier, than if it had been altogether at the mercy of the waves, that the objects should never go completely out of the field of view.

Hadley's principle thus formed an improvement of nearly as much importance to nautical, as the invention of the telescope had been to terrestrial astronomy. It was the first instrument which enabled marine observers to arrive at

at any respectable amount of accuracy in angular observation; and it has never been subsequently improved upon. It is consequently still in use, and in universal use, by the sailors of all nations; for whether their measuring instruments are known by the name of quadrant, sextant, reflecting circle, &c., it is still Mr *Hadley's* peculiar double-image principle which they are all employing. Other men, it is true, have from time to time been started for the honour of so lasting a discovery; and the friends of *Newton* and of high mathematics, have, with a good deal of reason, put forward that philosopher's great name, as having independently invented, though he did not publish the principle: while the *Americans* relate a story of an ingenious glazier in *Boston*, who, when taking fragments out of a broken pane of glass, suddenly saw the property of a second reflection, and thereupon ran like one distracted through

Competition for the honour of the invention

through the streets, with the two pieces of glass in his hands, and crying out, "I've got it, I've got it!" But close investigation by literary and scientific writers, and especially by the late Professor *Rigaud* of *Oxford*, gives the palm undoubtedly to Mr *Hadley*.

Many men, however, shared, and legitimately so, in the consequence of that gentleman's happy invention; for not only were all angular observations at sea immediately and greatly improved in accuracy by it; not only were the latitude, and the local time determined better than they ever were, or could have been, before, but a new method for the Longitude was found to be practicable by its means.*

New method of obtaining the local time of the distant meridian

This method was the now celebrated and classic one of lunar distances. It depends, as every one present must already know, upon that *proper*

* Philosophical Transactions, vol. xxxvii. p. 195.

Viz., by lunar distances

proper motion, as it is called, of the moon, by means of which this luminary appears to slide slowly backward every night past the stars in its neighbourhood; thereby presenting altogether a case very similar in principle to the passage of a clock's hour hand across the figures on its dial plate; and is capable, by due connexion with calculation and physical astronomy, of shewing to all meridians the state of the local time at the first or *European* meridian.

High part filled by Physical Astronomy

If we were dealing here with the entire subject of Nautical Astronomy, the means by which able mathematical astronomers have so admirably succeeded in making the above obscure connexion, and applying the *Newtonian* theory of gravitation to the motion of the sun, moon, and planets, so as to be able to predict their places for specified instants of time, years beforehand, and thereby enable a sailor in any part of the world, to infer at any given moment, by the particular

particular distance of the moon from a certain star, what hours, minutes, and seconds, the mean time clock of a *European* observatory must then be shewing, would necessarily occupy a prominent position in our discourse, as constituting the grandest illustration the world has yet seen, of what the human brain is capable of. But we are necessarily restricted at present to such parts alone of the practical problem as have to be performed by a navigator at sea; and foremost amongst these, comes the operation of measuring the said distance between moon and stars, with a degree of exactness sufficient for the end in view; a task not by any means so easy as might at first be imagined.

Present discourse requires to be limited to the observing part of the problem

Allow me, if you please, to explain why: In merely determining the *local* time at any place (under all circumstances the first half of the Longitude problem) say by absolute altitude of sun or star, an error of a degree in the measure will produce

Reduced scale of the Moon's proper motion

produce only about four minutes uncertainty in the time deduced; but in ascertaining the second part, or the *European* referring time, by lunar distance, the same error of measurement will produce more than thirty times as much error in the result; for by so much is the moon's proper motion less than the diurnal motion, and the scale of the one smaller than that of the other. With this reduction, then, of thirty times, it is that the hinted difficulty is connected, and to an amount which none but practical men can fully and truly appreciate.

The mere numbers do not immediately give a full idea of certain practical difficulties thence introduced

This statement may seem to be somewhat dogmatical; for, "do I not know what *thirty means*," might say almost any child in the present age of easy arithmetic; and, of course, he knows thirty as an arithmetical number, and knows a great deal more too, up to millions and billions and trillions. But it is precisely because our modern arithmetic enables

enables us to deal with large numbers so very easily, so infinitely more easily than could the Greeks, amongst whom it required all the intellect of an *Archimedes* in his *Arenarius* problem to express a few of these billions, that we cannot fully appreciate all the meaning sometimes contained in only two or three simple figures. How glibly can we, for instance, with our *Arabic* numerals, write down twenty, or thirty, or fifty, or whatever you will; but to *realize* one extreme or the other in many a practical proceeding, might prove toil and vexation of spirit to the ablest mind among us.

Example

Let us take a plain speaking case: Ask we a carpenter, "Carpenter, can you make a box of such and such a given length and breadth, and warrant that it shall not deviate from that measure by so much as one inch each way?" He replies, "Of course I can: even if I had only my axe and green trees to work with, I could keep within

Practical example continued

within such a large limit as that." "Can you," we ask again, "make it true to half an inch?" "Yes, certainly." "To a quarter of an inch?" "Yes." "To one-eighth of an inch?" "Yes," he still replies, but not with so much precipitancy as before, and stipulating, perhaps, for good materials and sufficient time for careful work. "And can you further make it true to one-sixteenth of an inch?" "I will try to," says he, if he is really an able workman. Then press him with, "Can you make it true to half a sixteenth?" "Half a sixteenth!" he exclaims, and then, after a pause, he sets forth that half a sixteenth is only an ideal expression amongst carpenters for the smallest conceivable fraction of length; they say that a drawer fits to half a sixteenth, when they mean that they have come to their *ultimatum* of finish and precision; but that actually half a sixteenth is a thing they have never seen, and a matter they never

never can be quite certain about; they may always be aiming at it, but the mere expansion and contraction of a plank from moisture, between winter and summer, would be quite enough to prevent their ever arriving at it. So, while any rude rustic can make the box true to within one inch, not even the best city carpenter, with all modern means and appliances, can always succeed in making it exact to "half a sixteenth."

Its application to the Naval problem

Now this rate, at which the mechanic's difficulty increases, as his limits of allowable error are decreased from an inch to half a sixteenth, is almost the same as that of the sailor; when, after having obtained towards his Longitude data *his own local* time, by a measure addressed to the large diurnal motion of any one of the heavenly bodies, he tries to ascertain the corresponding *European* local time, by means of the thirty times reduced scale which

which is afforded him in the proper motion of the moon.

Hadley's sextant peculiarly adapted to meet the difficulty alluded to

Evidently this is a case where the increased accuracy obtainable by *Hadley's* sextant was of boundless importance, and has caused that instrument to be, age after age, the scientific navigator's sheet-anchor. But even with it, the measure was so difficult, that no careless hand or inattentive eye could succeed; and after the observation itself was made, came the calculation, something far more intricate, with its corrections, depending on parallax and refraction, and their application through means of spherical triangles, than anything generally known on board ship. These were reasons why there was little true love early manifested by sailors for lunar distances; but they were also reasons that detracted naught from the respect in which such measures were obliged to be held, as the only safe and sound means of ascertaining

Lunar distances introduced into navigation

Naval

Naval Longitudes; surrounded with difficulties certainly, but such as carried no constant errors with them; and were of a nature to yield continually truer results, in proportion to the science and perseverance brought to bear in attacking them.

Lunar distances triumphant

Hence, on the whole, the lunar method, though slowly, yet surely, won its way to appreciation; becoming at length, towards the commencement of the nineteenth century, the only approved scientific process for Longitude at sea. Indeed, at last, none other was talked of or allowed, and lunars waxed mighty, and grew to be quite an *ultimatum* in naval education: so that to be a good hand at taking a "lunar," was a sure passport to promotion and favour; and to be fond of "lunars" was a proof of being certainly scientific. This was a grand time, consequently, for mathematical masters and teachers of navigation: spherical trigonometry was never so

so much appreciated in the nation. And why? It was so essential in the reduction of "lunars;" and without "lunars" there could be no safe navigation in long ocean voyages.

The third age is concluded

Such, then, were the characteristics of the third age, according to some the golden age, of the Longitude question; viz., the culmination of the *lunar-distance* method. And a noble solution it was; overshadowing everything else, from 1760 down even close to our own time. But now its glory has effectually departed; or at least its exclusive reign, as the *only* sound and orthodox means of ascertaining the Longitude of a ship at sea; for it is still of eminent service upon special occasions, and possesses some excellent features which are altogether peculiar to itself.

Peace and honour, therefore, be to its memory; and if it has been replaced on its former throne, by a successor speaking great and pleasant

pleasant things of accuracy easily obtained, that accuracy is of a rather fallacious and misleading description, unless a variety of special precautions and rare expedients be adopted, and constantly maintained, *in terrorem* over it.

The fourth age begins with ungeometrical notions

As might be expected then, not without dispute, towards the end of the last century was a new mode of Naval-Longitude observation allowed to appear, recommended though never so much by its marvellous facility.

Hard disciplinarians opposed it, and would insist on the old and rigorous lunar, despite all the trouble and time consumed; but practical men,—and many theoretical men too, who looked on lunars rather as means than an end, and not in themselves the *ne plus ultra* and perfection of all science, either for sailors or for landsmen,—were only too glad in their daily operations to profit by the easier method.

How

The chronometrical method of Naval Longitude

How much easier this was, will be understood at once, when I say, that it was the *chronometrical* method; wherein that ever difficult point for the sailor, of ascertaining, in a distant part of the world, the *European*, or for *Englishmen*, the "*Greenwich*," time at the instant, was not obtained by painful observations of indirect phenomena in the heavens; but simply by looking at the face of a portable watch, set, when leaving *England*, to coincide with *Greenwich* time, and still coinciding, or nearly so, with it.

"There is no *science* required to get the *Greenwich* time in that way; any one could do that," would say some disappointed *Lunarian*, or some would-be scientific man, vexed at seeing the ease with which he was passed by, in what he had long thought his strongest point. But, nevertheless, there *was* science in it, though not much spherical trigonometry of the

the old school; and some of the ablest minds amongst men had occupied themselves earnestly from a very early date, in trying to render so simple a method for the Longitude, available in practice.

Its early suggestion

Never too, perhaps, was there a better example of the wide difference between the abstract statement of a principle, and its successful practical realization; for though the former was suggested in this case of marine chronometers, by *Gemma Frisius*, as early as 1530, the latter was not arrived at before the eighteenth century; and yet such gifted minds as *Huyghens* and *Hook*, *Leibnitz* and *Bernoully*, had laboured long and earnestly upon it.

Late realization

The difficulty they had to contend with was mainly mechanical, or such as neither the hitherto favoured philosophy of *Aristotle*, nor even their own pure mathematics, availed them in much; and so it came to pass at last, that the

the earliest effective solution of the Longitude problem by chronometer, was reserved for a hard-headed, persevering, uneducated, or rather self-educated mechanic, a *Yorkshire* carpenter, born in 1693; by name, *John Harrison.*

Harrison's long continued labours

How and by what steps he was enabled to attain the goal which the whole learned world had been struggling for during 200 years, it is not for us now to attempt to investigate; but an idea of the amount of labour he must have expended on it, may be gathered from the fact, that, although he early left his father's bench, intent on making the discovery which ultimately fell to his lot, and although he had prepared, and even gone to sea, with one time-keeper in 1726, and with another in 1739 and 1749, it was not until 1764 that one of his watches, under the care of the then young Dr *Maskelyne* and Mr *Green*, was sufficiently perfect to undergo the ordeal of being taken to

Barbadoes

Barbadoes and back, and give the Longitude within a quarter of a degree.

Not, too, until that memorable occasion, was it definitively settled in men's minds, what species of time-keeper was likely to prove the best "chronometer" for Longitude at sea.

Earliest species of ship chronometers

The earliest claimants for such a distinction had been *clepsydras* and *sand-glasses;* some of them of very compound as well as ingenious construction; and though, with the experience of another century to guide us, we should not *now* think much of the exactitude or fitness of such machines, yet they must have been still in good repute in 1725, when *Daniel Bernoully* wrote his celebrated treatise on their arrangement and employment on board ship; and they had not lost all support from learned academies, or attention from scientific inventors, even so late as 1747.

An inroad, however, had been effected in their

Pendulum-clocks proposed by *Huyghens*

their domain by *Christian Huyghens*, in 1657, through the publication of his "*Brevis Institutio de Usu Horologiorum ad inveniendas Longitudines*;" one of the most remarkable tracts of an important period. Exalted ideas were consequently entertained everywhere, of what might be expected from the great *Netherlander's* clocks; regulated, as they were, by his modification of *Galileo's* pendulum: itself the most classically scientific attempt to insure isochronal motion that the world had ever seen, and with all the nameless prestige of nearly recent discovery still connected with it.

Of course, the opportunity was one that *Louis* XIV. could not allow to pass by without striving to make it bear an impress of his name, so ambitious of mundane immortality; and, before many years had elapsed, he ordered some of these promising clocks to be carried on board certain *French* ships cruising in the *Mediterranean*.

But

But the Grand Monarque found himself outstripped in the race by *British* subjects, and especially by a *Scottish* nobleman, the Earl of *Kincardine:* for this scientific lord, having had two pendulum-clocks constructed according to *Huyghen's* theory, committed them, in 1664, to the care of a "Major" *Holmes*, who seems to have been really a gallant Commodore; and who brought home before long, from distant voyages, most gratifying accounts of the performance of the new time-keepers.*

First trial of them at sea

So successful, indeed, did the result appear in those days, (though it was little more than proving on one occasion, whether the Major's fleet was near *Barbadoes* or the *Cape de Verde* Islands), that the song of triumph was prematurely raised for pendulum-clocks at sea. The States of *Holland* evidently believed; for they granted

Reputed success

* Philosophical Transactions, vol. i. p. 13; compare also, *C. Huyghens* De Horologium Oscillatorium, p. 17.

Huygbens's gains honour in *Holland*

granted *Huyghens* a patent right, gave up to him their long predestined reward, and "commanded him to bring one of these watches into their Assembly, to explicate unto them the Invention, and the application thereof to the Longitudes, which he did to their contentment."

Approval in *England*

Equally in *England* were men's minds carried away for a time, by the supposed *proved* adaptability of such clocks for sea-service; and accordingly, in 1669, the Royal Society of *London* published its creed, in a set of instructions for mariners, beginning—

"*Whereas 'tis generally esteemed that there* "*is no Practise for the* Finding of the Longitude "*at sea comparable to that of those Watches,* "*which, instead of a* Ballance-Wheele, *are re-* "*gulated by a* Pendulum . . ."

These remarkable views, however, were but temporary; for more extended experiences on the

the open ocean found the pendulums sometimes going most wildly, and sometimes stopping altogether; while never could they be got even to approach the test of accuracy demanded by the *British* Parliament; and yet that amount of test was perfectly necessary for the safety of practical navigation.

Negative results of further experiments

Men were thus thrown back on the "Ballance-wheele;" until at last through its means, in 1764, the humble *Harrison* produced his famous time-piece; and, as already related, completely satisfied both the Parliamentary Commissioners and the scientific public.

The balance-wheel finally preferred

Hence in real practical success, Longitude at sea by chronometer (as that term is now understood), had as early a birth almost as Longitude by lunars. But it was not yet possible for the method to spread. A watch had undoubtedly been made, fit to travel on board ship; but it was the product of a long life,

Limits to the spread of Chronometer Longitude in the eighteenth century

life, and of a genius without parallel; and who was to make another?

Extraordinary importance attached to *Harrison's* time-piece

Even in 1766, when *Harrison's* time-piece was to have its rate tested at the *Royal Observatory*, it was looked on as a something of almost awful value; "Dr *Maskelyne* received it at *Flamstead* House," we read, "from the hands of Sir *Philip Stephens*, Secretary to the Admiralty; and then in the presence of Captain *Thomas Baillie* of the Royal Hospital, *Greenwich*, and of Mr *John Ibbetson*, Secretary to the Board of Longitude, and of Mr *Larcum Kendal*, Member of the same Board, it was deposited in a deal box made purposely to contain it, with a glass case made secure with putty. The box had two locks of different wards, and two keys to each lock, also a pane of glass in the side secured with putty; and whenever the piece was afterwards wound up, one of the keys was used by

Dr

Dr *Maskelyne*, and the other by Captain *Baillie*, or one of the officers of *Greenwich* Hospital; and the constant formality of a written testimony was used, we are told, not only when the piece was wound up, but also when a comparison of it and the Observatory regulator was taken and registered. Dr *Maskelyne* afterwards published the results, under the title of, '*The original Observations of the going of the Watch from Day to Day*,' in the form of a quarto pamphlet."

Difficulties of mechanical repetition certain to be overcome in time

There is, however, as is well known to engineers, this prevalent feature running through all mechanical inventions: that whatever one man may have contrived and executed once, though with extraordinary difficulty, can, in course of time, be made with facility by workmen specially educated to the task. In this way it came, that alleged impossibilities with regard to the steam engine were overcome; for when

Example from the history of the steam-engine

when *Watt's* first engine was made to work with a close cover, and was proved to work well, it was still held to be only a curiosity; because, said critics, such extraordinary nicety as was required in turning the cylinder and piston rod, would be ever above the range and capabilities of engineering work-shops. Yet look round now, and see how, not only in the old *Soho* establishment, but in almost every city in the land, from one end of it to the other, there are factories where similar cylinders and piston rods are turned out daily and even hourly, all working as well as *Watt's* original one, the wonder, and deservedly so, of all his contemporaries.

Similar result arrives slowly in chronometer making

Much the same has been the history of chronometer-making, subsequently to the crowning of *Harrison's* celebrated specimen, known in his day as *par excellence*, "the Watch," "the Piece," &c.; though the final result

result in this case was slower in being arrived at than with the steam-engine. Numerous skilled mechanics did, indeed, immediately apply themselves to the task, and before many years succeeded in producing watches or pieces that would keep fair time on a voyage; yet, after an interval of forty years, as we learn from the celebrated taxation remonstrance of the *London* watch-makers to Mr *Pitt*, the cost of the labour expended on a first-rate time-piece, where the value of the raw material was only sixpence, actually amounted to £500.

High prices of the earlier chronometers

Harrison's chronometer had cost the nation £20,000; this reduction, therefore, to £500, was a most notable one. But even at that reduced price, it is evident that Longitude by chronometer must have remained a luxury not to be enjoyed by many vessels. Happily, however, division of labour, with special education of workmen, was still going on; and a few years more

Chronometers cheapened, and multiplied in modern times

more saw prices reduced successively to £100, £50, and at last even £20. And now, what ship is there which cannot afford to carry one or two chronometers? while in that room at the *Greenwich* Observatory, where, in 1766, "the piece" was received with so much formality and so many witnesses, there are now generally above a hundred similar "pieces," with their innumerable tickings, making such a general buzz, that a stranger on suddenly entering, fancies he must have stepped into some beehive establishment at the moment of a general swarming.

In fact, both the Royal and the Merchant Navy are now abundantly supplied with chronometers; and if the mere possession of one was everything, no ship that leaves our shores need ever be in danger from erroneous Longitude.

The mere possession, however, of a chronometer

meter, as already hinted, is by no means enough to insure safe navigation; for, unhappily, so severe is the probation of competing with the earth for accuracy and regularity of motion, that nothing human can altogether withstand it; and hence, in such a service, the best time-piece constructed by the hand of man, is to be viewed only in the light of an imperfect machine, which, unless checked and corrected from time to time by reference to the heavens, may seriously mislead in its indications.

The best chronometer needs "rating"

Nevertheless, if absolute perfection has not been reached, another and a very useful quality has been attained by the skilful workmanship of modern watch-makers; and leads to this, viz., that good chronometers do not change their rates quickly. Hence, they may be depended on pretty safely within certain limits, during given lengths of time: but evidently the shorter these lengths of time, or the more frequently

Observations for the *rate* to be obtained whenever in port

frequently the watches can be compared with the skies, the better. These preliminaries being granted, frequent determinations of the *rate* of chronometers become the chief part of their economy in navigation; and as such rate cannot be arrived at distinctly when on the voyage, every opportunity should be taken, on entering any harbour, for instituting the necessary observations.

The celestial part of such measures need not indeed be made by every captain of every ship in a large port; for one person, after he has obtained the true time, from sun or star, may, by an appropriate signal, make it serve the purposes of all the rest, with a great saving of their time, and much advantage to the end in view; and some plan of the sort has not unfrequently been employed on particular occasions. As, however, there were found to be many difficulties in the way of sailors establishing

establishing such a system permanently for themselves, the Government of the country was led to assist them; and, appreciating all the importance of the occasion, as well as the duties and responsibilities of their own position, they made an excellent beginning about thirty years ago.

Government plan for the Port of *London*

This consisted in establishing a peculiar signaling apparatus at the *Greenwich* Observatory, so that the Astronomer there might, by such means, daily notify to all ships in that part of the *Thames*, the chronometrical result of his latest observations; and thus furnish them with the celestial time, ready to their hand, and with greater accuracy than they could procure it for themselves, with their usual sextants and quadrants.

So much practical advantage was immediately derived from this method, that it soon became, under the name of the "Time-Ball,"

a permanent and important feature of the *Royal* Observatory, equally referred to by watch-makers and professional chronometer-raters on shore, as by skippers and mates on the river; and before long, in compliance with the earnest desires of the shipping interest, similar Time-Balls were erected, either by the Honourable *East India* Company, or by Her *Majesty's* Government, at *St Helena*, the *Cape* of *Good Hope*, *Mauritius*, and *Madras;* their erection at those places being facilitated by astronomical observatories having been previously established there. While at *Liverpool*, where no such preliminary advantage existed, the authorities saw so clearly what would contribute to the safety of their ships and the advantage of their port, that they not only established a Time-Ball near the docks, but founded an excellent Astronomical Observatory in connexion with it, and

Similar methods adopted in some other ports for ocean shipping

and appointed an able Astronomer to the charge.

The *Edinburgh* Time-Ball

In *Edinburgh*, where the noble efforts of the late Astronomical Institution had already supplied the *Calton* Hill with a first-rate Observatory, which has been subsequently fully adopted by Government, the question of having a Time-Ball was frequently agitated from an early period; and it was by no means from any want of local appreciation, that the idea was not carried out practically until 1853. The machine, however, then erected, at the expense of Her *Majesty's* Government, is probably one of the most perfect in existence, and has certain electric contrivances for insuring the accuracy of its manipulation, such as were quite unknown with the earlier instruments.

Electricity employed at *Greenwich* to work subsidiary Time-Balls

This application of electricity had, however, it is proper to say, been first introduced by Mr *Airy*, at the *Greenwich* Observatory; and is

is employed there now to a remarkable extent: for not only does one electric signal drop the *Greenwich* Time-Ball, but it is caused simultaneously to drop a second one in *London*, and a third at *Deal;* thus extending, far and wide, to ships on the south as well as south-east coast, the opportunity of testing their chronometers, with all the accuracy of the best astronomical observations from the *Royal* Observatory.

Similar experiment between *Edinburgh* and *Glasgow*

These supplementary sympathetic Time-Balls are a new and important feature in our time; and although they are not yet regularly established in *Scotland*, an illustration of their action, and the possibility of similarly extending the utility of the *Edinburgh* Observatory, was given here as far back as 1855. For, by means of arrangements made, at the expense of General Sir *T. Makdougall Brisbane* (who has, for half a century, struggled to make the import-

ance

ance of a knowledge of the true time in Longitude questions, by sea and land, appreciated in the nation,) with the Electric Telegraph Company—*Glasgow* being included in a loop from the electric circuit between the *Edinburgh* Observatory and *Nelson's* Monument—a model Time-Ball was dropped daily for a week in the *Western* capital, simultaneously with the *Edinburgh* signal.

Time-guns proposed

Similar plans have been proposed for some of the *Eastern* and *Northern* ports of *Scotland;* not only, too, for their docks and harbours, but for their prominent headlands, the real points of departure in long voyages. While, within the last few months, this Chamber has had before them the practical proposal of Mr *Hewat*, for adding *audible*, to the *visible*, signals of true time afforded from the *Edinburgh* Observatory, by having a *cannon* fired, as well as a ball dropped, by the electric circuit. And

And there can be no doubt that such signals, duly corrected for distance, may be of infinite service to both the chronometer makers and the ships of *Leith*, during those long periods of thick winter weather, when neither the Time-Ball nor *Nelson's* Monument can be seen at the distance of a mile.

Near and honourable completion of the *fourth* age of Marine Longitude

Duly considering then, gentlemen, all these recent improvements, completed, begun, or in contemplation, there can be little doubt that the tide is now setting in strongly, to establish and perfect in our day the *fourth* and, on the whole, the most practical age of the Longitude at sea, viz., the age of chronometers. For, let there only be a few more sympathetic Time-Balls; and, wherever there is an artillery station, Time-*guns* electrically fired from a central Astronomical Observatory, and then, whenever a sailor sights any coast of this country, he will have the means at once of obtaining

obtaining, and without any trouble or delay, all that he has long been desiring, to solve one of the deepest mysteries of old, and to remove the chief of all the dangers once experienced, and still to be guarded against, in ocean navigation.

Having then, Mr President, the Longitude question thus brought down to our own day, with but a little filling-up work of a straightforward and simple character, requisite for completing the grand outline long since drawn by our ancestors, there may be some present who might possibly be inclined to give utterance to the cry of "land a-head," as I am informed the sailors in the forecastle occasionally do, when, after reading through two-thirds or more of some standard novel, they just begin to have a faint perception of how poetical justice and halcyon days are about to be distributed amongst

Will everything be perfectly satisfactory when the objects of the *fourth* age are completely obtained?

amongst the *dramatis personæ* of their tale. And, indeed, some of the circumstances of our Longitude case are such, that any one might well be excused for beginning to hope that land, and rest and quiet, are really now before us.

Our *whole* task, however, has not been yet accomplished; and while from the landward side of creation we are often warned, that it is by no means safe "to holloa before one is out of the wood," so from some of seamen's reading experiences we also learn, that when they chance to forgether with a work of fiction by an author of more than ordinary power, and haply fancy that they have, very early in the tale, ascertained the drift of the plot, or as they express it, "touched soundings," suddenly new complications arise, and away the readers are whirled amongst new scenes and new characters, and the latter end of

Doubts suggested

of the story is very different from what had been expected near its beginning.

If such, then, be a caution derived from the works of one man of somewhat more wisdom than his fellows, what ought not to be the amount of respect with which we approach, and venture to predict upon, the conclusions of any phenomena in *Nature?* There, indeed, those who have pursued original investigations know full well, that, perpetually as they may succeed in arriving nearer and nearer at the goal they have long been aiming at, so do fresh difficulties arise; and actually at last, every property of matter seems bent on opposition to prevent a full, and complete degree of exactness being ever attained by mortal man: thus compelling him to confess, that perfect truth is an attribute of the *Deity* alone.

Difficulties increase in number, the more accurately natural phenomena are observed

We have not, it is true, now to deal so much

The same feature exists in useful and practical applications of science

much with those well-known features in the pursuit of pure science, which demand that the seconds, forming the limits of sufficient accuracy to a previous generation, be cut down to tenths in this, and to hundredths in the next age, as with the practical employment of old and well ascertained branches of knowledge, in every-day professional occupations. But these employments have, it is notorious, their own peculiar trials and requirements continually increasing in severity; most startling, too, sometimes, in their newness and, not seldom, almost infinitely difficult to fulfil.

Felt in Navigation

Thus, in our present subject, we cannot conceal from ourselves that remarkable phases have come over both shipping and commerce, during the long period that the perfecting of the chronometrical method of Longitude has been occupying; and to such an extent have they reached at last, as now to render absolutely

lutely necessary some further and by no means easy elaborations, in the practical branches of the general problem, for ascertaining geographical position at sea from astronomical observations.

Progressive change in naval architecture and practice during late years

It is altogether subsequent, for instance, to 1764, that steam-vessels have appeared on the waters; or the railway system been inaugurated, and manufacturing operations on a great scale, with immense elemental power at command, been carried out on land. However different, too, these specified examples may at first appear from each other, they are, in their origin, intimately connected; and are all equally expressive of the general movement that is characterising the mind of the nineteenth century, and carrying with it the destinies of our nation and the fate of the world.

Demands an extension of Longitude methods

With seriousness, therefore, if not reverential fear, should we attend to the changes that have taken place in our own particular walk, on

on finding how deep is their origin, and how extensive and irresistible their influence is likely to prove. And, while one of the results of the general movement, indicated above, has been, everywhere and in everything, a demand for continually more punctuality and more despatch than was sufficient of old, it is noteworthy, that this behest has been less satisfied in some points of navigation, than anywhere else by sea or land.

Chiefly in connexion with measures for altitude

The deficiency here arises, in large part, from the apparently small cause, of the limited powers of the principal astronomical instrument by which the course of ships is ascertained and directed: for this instrument, *Hadley's* sextant, only admits of being employed in any Latitude and Longitude measures when the sea horizon is visible; and as this is seldom or never the case at night, no use can be made of any of the stars which then appear.

Under

Under these circumstances, when an ocean ship arrives near the end of its voyage, by chance, towards evening, in cloudy weather, with its geographical position rather uncertain, it must lay-to idly all night, in expectation of the next day bringing a bright sun and clear horizon; throwing away in this manner as much valuable time as would suffice to make, or unmake, thousands now-a-days. Or, if a bolder course be taken, and the voyage pushed on, through mist and darkness, why, sometimes fortune favours the "happy-go-lucky" system; but, sometimes, also, one of those dismal cases will occur, which every now and then so shocks humanity, and goes to make up the hideous annual number of 1100 *British* wrecks; viz., a case of some magnificent ship, with hundreds of passengers on board, striking on the rocks by night, and every soul perishing miserably, almost within reach of their own country. Yet,

Importance of observing at night

Superior night practice on shore

Yet, at the very same instant, in a fixed Observatory on land, where sextants are not the only instruments that can be employed, the stars at night are constantly being observed; and are greatly preferred to the sailor's usual celestial mean, the sun, wherever accuracy is required.

Hence the *Edinburgh* Signal-Ball is invariably dropped according to time procured from stellar observations; while every scientific traveller, or geodesist, knows full well, how much better he can determine his latitude and longitude by stars, than by the heating luminary of day. Strange is it, therefore, to hear, that the mariner, who has ten times greater need of correctly ascertaining where he may be during the dangerous hours of darkness, is, for such occasion, no better off now than he was in the age of *Columbus*; and has at last come to be quite content, perforce, of the incapacity of

of his sextant for night observation, simply to fold hand over hand, and wish to God it were day.

Surely, gentlemen, this is not a right or creditable state of things for the Nautical Astronomy of the latter half of the nineteenth century; or, in other words, here is an evil, great and crying, which is well worthy all the efforts of the philanthropist and the scientist, the merchant and the Government, to endeavour to alleviate.

Necessity of improving the mariner's means for observing stellar altitudes at sea

Let us seriously consider it: Commerce and the world now require, that as much use should be made by a seaman of the stars by night, as of the sun by day; but he is unable to satisfy the demand, to some extent, because even the brightest of the former class of objects are only very faintly seen in a sextant telescope after the usual two reflections; but mainly, because the sea horizon, or referring line

line for sextant altitude, is not visible during all the nocturnal hours.

The scheme proposed, adds to, rather than subtracts from, the usefulness of chronometers and time-balls

The question then, though still to be called "*of the Longitude*," is thus shifted, it will be observed, on to other grounds than those hitherto occupied; for it is no longer, as of old, a better way for the navigator to obtain a knowledge of the *Greenwich* time, but a better instrumental apparatus for measuring, under special circumstances, the celestial *altitude*, from which he is to deduce *local* time, and sometimes his *Latitude* also, that is wanted. Hence we have at least the satisfaction of knowing, that all we have been doing connected with Chronometers, and Time-Balls, and all that we may yet do, with additional sympathetic Time-Balls, and perhaps Time-Guns, holds perfectly good; and not only so, but will be made more effective and more valuable still, if human invention can ever bring

bring about, that observation at sea for the *local* time, or more generally for *altitudes*, shall be rendered possible to be arrived at accurately, by night as well as by day.

The difficulty, therefore, so far as its statement and description are concerned, is all contained in a nutshell; and one would even think that its solution cannot be very far off, when nothing is more simple than for any one *on shore* to do all that is needed, (viz., to measure an altitude of a star at night, without reference to the sea horizon). A moment's inquiry will, however, shew that the case is one of extraordinary perplexity.*

Wherein consists the practical difficulty

The land observer uses for his referring point a plumb-line, or, what is equivalent, the surface of

* "—— difficultatem tamen superari posse semper speravit, multa tentavit, et ad mortem fere usque nova, ut ad scopum perveniret, molitus est: sed licet ad hunc pertingere non potuerit, quo ingenio, qua perspicacitate, rem prosecutus est."—*Hugenii vita*, 1724.

"Il y a cependant dans ces matieres, bien des choses très-fondées, qui paroissent démenties par l'experience."—*D. Bernoulli*, 1747.

of a fluid, shewing the direction of gravity truly, because acted on by it alone. But these indicators become perverted and inconstant at sea, because the motions, and especially the disturbed character of the motions, of a ship, interfere with, and often overpower, the effect of gravity; and send plumb-lines and fluids swinging or spilling to the right and left, through immense and ever varying angles, and in every direction but the true one. The more sensitive too, that any of these indicators may be to gravity, the more it is disturbed by the disturbances; while, if we could get anything altogether uninfluenced by the disturbances, it would be found quite incapable of shewing the direction of gravitating energy at all.

Short cut suggested

The case is thus much worse than that of *Scylla* and *Charybdis* of old. No wonder, therefore, that *Daniel Bernoulli*, after applying

ing all the resources of his powerful mathematical mind to the subject, for more than twenty years, was at last driven—in utter despair of ever correcting these derangements of gravity-indicators on board ship, and rendering such instrumental appliances safe and true for measuring celestial altitudes from—to exclaim, that he saw no way of proceeding, but to *cut* the *Gordian* knot which refused to be *untied;* and if all these complications arose from the sea-horizon not being visible at night, why, *make* it visible, said he; and there are ways, he added, by which that may be done. As no method, however, has been proposed, either by him or any one else, except what is *Utopian* in the highest degree, the knot is still uncut; and to be rendered serviceable to the masses, must be deliberately untied.

Found to be inapplicable

This mention of the great *Switzer*, and the reference in the note to the philosopher of *Zulichem*

The problem by no means new

Zulichem, shew that the subject has, on one account or another, been long before the world; and, indeed, from the earliest times, some sort of use has always been sought to be made of the stars, in navigation; so, when modern improvements in astronomy and optics, had enabled the local time to be correctly deduced from a well-measured altitude of the sun, it was only natural that men should try to get the same result from one of the stellar host. As often, however, as they tried, so often did they fail; until at last it became a settled maxim among sailors, to confine altitude measurement to daylight alone.

But brought into much more prominence and importance in recent times

This was a restriction, as we have already remarked, which the slowness of navigation, and the affairs of the world in general, permitted of old; but we are living in other times, and have been undoubtedly born to the responsibility of solving this problem of our fathers,

fathers, and of solving it, too, with all despatch; lest the progress of commerce, civilization, and, in thus far, of the human race, so gloriously carried on by them, should be retarded in our day.

Essential step in commencing

Excuse me then, gentlemen, I pray you, for the cause's sake, if I now take up this matter in a more than usually dry and business-like manner. Excuse me too, I especially beseech you, if, at the outset, I assume so apparently ungracious a part, as to insist that everything which has been yet invented for our present problem (and many of the instruments so invented have displayed extraordinary skill and ingenuity,) has utterly failed in practice: duly remembering, as I trust you will, that it is absolutely necessary to real success in any scientific pursuit, to begin by thoroughly purging our souls of all false and flattering

flattering unctions, either of self-love, or of antient prejudice.

Rumours of success already arrived at

Thus compelled, therefore, by the principles of philosophising, I have no hesitation in making the assertion, although perfectly aware, that from time to time one hears, that, with such and such an apparatus, a naval altitude *can* be, and actually has been, measured at night. An implement, indeed, of the sort, and one that may serve as a general example, devised by a very able and scientific officer of the *Royal* Navy, has recently been rewarded by Government; and there is even now a discussion at the *Admiralty* about its general adoption in men-of-war.

This appliance, attached to an ordinary sextant held in the hand, obtains the direction of gravity through means of a short pendulum, immersed in a vessel of oil, to check its disturbed oscillations; and if it is actually as capable

capable as has been recently reported, our main difficulty is solved, and we have little more to do.

Similar rumours more than a century ago

A report of actual trial, must, of course, carry with it considerable weight; yet the manner in which the trial is conducted, may sometimes be of greater importance; and if in this particular problem, we were to trust implicitly to an official report, without inquiring into all the attendant circumstances, there is as much evidence that the end was gained in 1738, when "Mr *Leigh*, Gentleman," produced his mercurial levels attached to a "*Davis's* Quadrant;" and when four naval officers of his *Majesty's* ship, *Oxford*,* attested to having experimented at sea with this contrivance, under most crucial conditions, and to its yielding results not differing more than one minute from the truth; in fact, with less

* Philosophical Transactions, vol. xl., p. 423.

less error than many of the trial observations of *Hadley's* immortal sea-horizon sextant; or sufficiently close to perfection, to have successfully established it amongst seamen, and to have rendered it absolutely impossible to be forgotten amongst men.

Disproved by time and experience

Impossible to be forgotten; because a really practical invention, for any of the necessities of daily life, is in itself as durable as the race of man upon earth. The inventors themselves may be lost in oblivion, as have been those of the plough and the saw, but not their inventions, which are handed down from age to age, and from race to race, with continually increasing assurance of perpetuity: just as each successive year, from the birth of gunpowder and the steam-engine, has established them more securely as the future companions of man, inseparable from him in all the vicissitudes through which he must pass, before

fore arriving at the end of this dispensation.

Not allowed by the *French* Academy

But where is now the naval quadrant of "Mr *Leigh*, Gentleman," and where, indeed, was it, even so soon after its invention as 1745, when the Academy of Sciences in *Paris* proposed, as the subject of a prize, a matter which their high authority considered was still unsolved by man, viz., "On the best manner of finding the Time at sea, by observation, whether by day, or in the twilight, and *especially at night*, when *the horizon is not visible?*" We may answer, that Mr *Leigh's* mercurial-level quadrant had no place among all the five long treatises competing for the prize, and published by that learned Society, in 1750: and as little, too, was there thought of the nautical efficacy of a "pendulum swinging in oil," though there had been at that date upwards of fifty years to try it in.*

Even

* "Machinæ quædam, et varia circa mechanicam," of *C. Huyghens.*

Even the learned Academicians invented nothing to satisfy the Council of their body, in that special part of its proposition, "*et surtout la nuit, quand on ne voit pas l'horizon;*" and they were sent back to study the subject for two years more.

The Prize Essays of 1747

Additional Memoirs were, accordingly, furnished in 1747, and the prize was divided between two of them; but their success was still so ambiguous, that the Academy expressly advertised, that it did not concur altogether with the authors; and only one of the five allowed his name to transpire. He was the immortal *Daniel Bernoulli;* and though he may have failed in bringing about a practical correction for the end in view, his monograph on the several conditions of the problem is not only well worthy of study, but is still one of the completest and most philosophical that has yet appeared.

Equally

Early mechanical suggestions

Equally rich is the treatise in mechanical suggestions. In his pages, accordingly, and those of his companions, viz., "*Arbor non uno sternitur ictu.*" "*Nihil unquam invenietur, si contenti fuerimus inventis.*" "*Nautam ne pigeat cœli convexa tueri;*" and "*Semper id melius quod optimo propinquius est,*" (for only by their mottoes can we speak of the several writers,)* are to be found pendulums, simple and compound, free and swinging in oil or water; the double reservoir of fluid, whether water, alcohol, or mercury, communicating by a throttled aperture; the oscillations of a suspended body impeded by friction of axles, &c.; and other similar inventions, occasionally, but unavailingly, resuscitated in modern times, after long periods of that deadness and oblivion, which so surely

* One of them additionally exclaims, "Terricola heu prorsus sum inglorius; ô ubi pontus et naves? O qui molis me in vertice sistat, aëriæ cœlique vias et sidera monstret?"

surely befall in the end, every ineffectual contrivance.

Now, all the above-mentioned plans of the Academy's prize-men in 1745 and 1747, also of *Bouguer* in 1729, *Bernoulli* in 1725, *Huyghens* in 1670, *Leigh* in 1738, *Elton* in 1732, and *Hadley* in 1733, for he, too, worked in this field, it is most important to remark, are based on true principles; in so far as they will, undoubtedly, answer well on land. They will even do more than that, for they will answer to *some* extent at sea.

Where they succeed, and where they fail

To *what* extent, does any one ask! Aye, there is all the gist of the question. In a land-locked harbour, where the surface of the salt water approximates to that state which a theorist is too apt to assume for it generally, there may be pretty respectable performance; but, out on the open ocean, amid such lurches as those of the *Agamemnon*, with the electric telegraph

telegraph cable on board, there could be nothing practical attempted; yet that would be precisely the time and place when an accurate altitude result would be important; and any method that should be found effective there, would, *a fortiori*, suit quiet water also.

To these lurches then, and to all the most violent and unexpectd motions of a ship, when most rudely tossed about by the waves, we must specially address ourselves; and, instead of taking up the subject, *a priori*, and insisting that all our equations for the oscillation of a floating body as an inverted pendulum, are founded on the strictest theorems of mechanics and hydrodynamics, and must be true, let us make a few inductions from actual observation at sea.

New inventions for this purpose, to be successful, must be proof against "disturbances"

In a comparatively small vessel, *i. e.*, 140 tons burthen, but in moderate, or at least not stormy, weather in the open *Atlantic*, I had

Angular amount of rolling in ships at sea

had an opportunity lately of ascertaining, by measure, the average amount of angular rolling in that case, to be equal, in the course of a minute of time, at the rate of twenty rolls of about 15° each, to 300 degrees: that is, 5° in one second; 30′ in a tenth of a second; and the required quantity, and the quantity often reputed to be reached, of 1′ in .003 of a second. Unless, therefore, the pendulum, quicksilver, spirit level, or other gravity indicator employed, move and adjust itself thus quickly, we may at once infer, that it must always be sensibly behind, and in error, with its indications.

Too quick for the quickest of gravity-indicators to keep up with

Now, none of these instruments, even in their freest state, are anything like so quick as this in self-adjustment; and in proportion as they are surrounded by oil medium, or checked by throttling, strings, and other means, so do they necessarily become slower, and require whole

whole minutes, instead of thousandths of a second, to attain their just position after any move either of their base, or of their point of suspension. In which case it is evident, that from this cause alone, the altitude will only be obtained to a handful of degrees, instead of the requisite exactness of one minute of space.

Disturbances of gravity-indicators arising from irregularity of ship's rolling

On the other hand, if the gravity indicators are freed from all trammels, and are made more able, though never by any means completely able, to follow, and keep up with, the nimbleness of a small sailing-vessel's angular motions; then, by exactly the same degree, are they disturbed, and at last terrifically disturbed, by the variations occurring anomalously, among all the successive rollings, which go to make up the average 300 degrees already spoken of.

The excessive variation amongst the rollings

lings can hardly be credited, until careful numerical observations are instituted; and though experienced seamen do talk of the long regular roll in the open ocean, and though it *is* sometimes very much more regular than at others; yet, even in the middle of the *Trade* wind region, the part of the whole world most conducive to regularity in ocean undulations, we could seldom get any numbers more coincident than as follows:—18°, 23°, 19°, 6°, 14°, 2°, 19°, 17°, 4°, 9°, 6°, 12°, 7°, 10°, 11°, 23°, 5°, 12°, 11°, &c.*

As these figures never seem to repeat themselves, and are occasionally broken into by a suddenly curtailed, or an extended, oscillation, as some special wave unexpectedly breaks or hits the vessel, it is impossible for any man to know precisely what is coming; and to eliminate its effects, to anything like so small

a

* Transactions of *Royal* Scottish Society of Arts, 1856-7.

a quantity as one minute of space: while the usual method that is recommended for observing *regular* oscillations, viz., reading off both ends of the arc of vibration and taking the mean, is found here utterly to fail in meeting such excessive irregularities.

Additional disturbances from the "pitching" and "yawing" of ships

Nor is this all the difficulty, for besides the "rolling," there is the "pitching" going on all the time, and the "yawing" too,—all of them variable and compounding variously into each other, and producing angular disturbances in every possible plane. This might seem to be enough; but there is more still, the waves have unhappily more, to be eliminated; for beyond all these *angular* movements, is the accompanying bodily *translation* of observer, instrument, and everything about him; backwards and forwards; arising from the distance of the ship's deck from its centre of motion, and producing yet more perplexing

ing anomalies in the action of every kind of gravity indicator, that has up to this time been published to the world.

In short, when confined to such methods, impossibility of success, and despair of ever reaching a practically satisfactory result, seemed to arise on every hand; and at last nothing remained, but the Professor of *Basle's* proposed cutting of the *Gordian* knot, viz., *making* the sea-horizon visible at night—if one could; whether by fire ships, by setting the sea in a blaze, or by any other plan.

Hope inspired by reference to the phenomena of the earth's motion

Looking round, however, to the rolling ocean, and then to the stationary Pole, the thought had occurred to me sometime previously,—behold how steadily the earth, thanks to the free rotation on its axis, keeps its angular position in space, spite of disturbing forces; cannot the same principle then be brought to bear, in facilitating, by at least one step, the

the solution of this most troublesome problem in navigation?

Nautical applications of the spinning-top principle by *Serson* and others

The idea was not altogether new, for an attempt had been made to turn to practical account the habitude and motions of a spinning top, by Mr *Serson*, sometime previous to 1744; subsequently by Mr *Weir*, with the assistance, and at the expense, of the Board of Longitude; and finally by Mr *Troughton*, in 1820.* These several inventors, however, did not meet with success at sea; though their "horizontal tops" very strikingly exhibited some remarkable effects of rotation, and led the way to the invention of *Bohnenberger's* Precession machine in 1800, to *Sang's* suggestion in 1836, for proving the rotation of the earth, to the Rev. *Baden Powell's* Lectures at the *Royal* Institution, and to *Foucault's*

* *Brewster's Edinburgh* Cyclopædia; article, Sextant.

cault's exhibition of *Sang's* idea at *Liverpool* in 1854.

Aware of such failure, but thrown by the necessities of the naval altitude case to think of free revolution as the only relief, I examined a specimen of *Troughton's* top, sensibly modified from, and supposed to be improved on, *Serson's*—and soon found that it did not fully bring out the principle which I at least sought to embody.

Latest form of *Serson's* horizontal top

The instrument was something like an inverted metal cup, poised on, and turning upon, the summit of a fixed upright spike, and with its rim depending below the point of suspension. In this state, the arrangement was a species of circular pendulum; and the upper flat surface being garnished with a mirror, a reflected altitude observation might be taken from it; on shore, with some truth; but at sea, with all the wabbling and disturbance

bance of an ordinary plumb-bob, whenever exposed to the effects of rolling and pitching. The inventor had, indeed, found, that if, by appropriate wheel work, the cup were set spinning upon its support, at a rate of about 20 revolutions in a second, no wabbling was caused by any moderate disturbance to the base of the instrument; and he fondly hoped that it would, therefore, remain perfectly steady and level.

Its intended action

Here, however, he was mistaken; for the forces or disturbances of a ship, which cause an ordinary pendulum to oscillate, are present to act on the revolving pendulum also; and though their effects, being compounded into the rotatory motion, are not *immediately* apparent, yet they soon produce a sort of "precessional" gyration, which at last may set the reflecting plane at almost any erroneous angle. At sea, too, even at the very starting of the top,

Its failure; and wherefore

top, it may, or even must, be more or less out of perfect horizontality; and then there is no longer "*free* revolution;" for the weight below is always constraining the instrument to one certain position more than another; setting up thereby an additional "precessional disturbance," to the utter confusion of all attempts to determine celestial altitudes with scientific accuracy.

These inevitable misfortunes would seem to have arisen, in no small degree, from the *spinning of a top*, rather than the *rotation of a planet*, having been before the eyes of the inventor.

Higher example in nature

Let us, then, look steadily to the celestial phenomenon; and one lesson which it should immediately teach us, is, the propriety of clearly separating two subjects, hitherto much confounded, viz., the preservation of a constant angular plane; and, the ascertainment of the

the bearing of that plane, with reference to the direction of gravity.

Division of the problem into two portions

On this principle, only secure to an astronomical instrument on board ship, perfect immunity from all angular deviations; and then you will have, in the gravity-indicators that you must afterwards apply, nothing but the effects of translation movements to guard against; and these, by themselves, are comparatively easy to deal with.

Practical characteristics of terrestrial rotation

Legitimately, therefore, and on workmanlike principles of procedure, the first thing to be considered in our present problem, is, the elimination of movements in angle; and this is precisely the point wherein planetary rotation presents the best example we can follow. In the case of the earth, we may sum up this feature practically, under the two following heads:—No. 1, revolution on an axis, with a circumferential velocity at the equator of

of 1500 feet in a second; and, No. 2, perfect freedom from all mechanical obstruction to the axis changing its direction in space, if inclined so to do.

These are the characteristics, then, which must be imitated in machinery, as far as possible; and, with the leave of the Chamber, I will venture to relate, in a few words, what little progress I have been enabled to make herein.

Their imitation in a machine

A heavy disc of gun-metal, one foot in diameter, in figure, exaggerating the earth's equatorial protuberance, has been constructed; and furnished with a steel axis, to which motion has been applied, first by wheel-work, then by water, and finally by high-pressure steam—until the rather satisfactory velocity of 120 revolutions in a second was attained. This fly-wheel, with its bearings, was then mounted in two gimbol-rings, the directions of whose pivots

pivots crossed each other at right-angles, and passed through the centre of gravity of rings and disc.

The axis was thus "free," or enabled to change its direction without any other impediment than the friction at the ring-centres of motion. These were purposely made very delicate and smooth; but as they exerted, notwithstanding, a sensible drag, the "freedom" of the apparatus fell far short of the earth's theoretical perfection in this way; while the highest velocity, was only one-fifth part of the terrestrial, at the equator.

Shortcomings in what has yet been done

Yet the action of this diminutive model, in preserving a given plane, was astonishingly powerful; and, indeed, at first sight, almost magical to contemplate; for, once placed, so as to point towards the zenith, the little spinning axis would remain sensibly true to that, as its pole, no matter what amount of angular

Large amount of effective action, owing to truth of principle

lar disturbance might befall the so-called fixed frame, in which its supporting gimbol-rings were hung.

Tested at sea

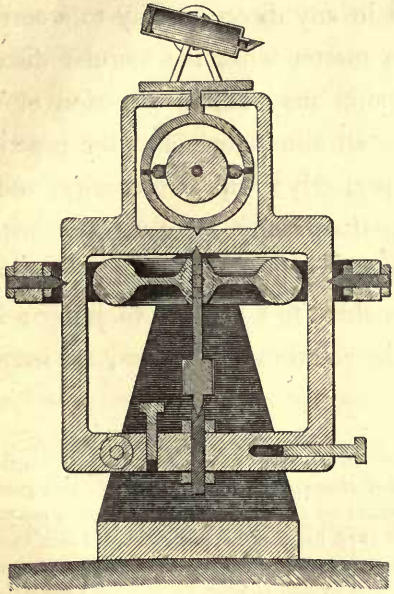
A small astronomical circle and telescope were next attached to the bearings of the revolver wheel; and the whole arrangement being then tried on the open ocean, with the plane of rotation approximately horizontal, all the rolling and pitching motions of the ship were so completely eliminated, that for a period of several minutes a distant level line remained approximately bisected.*

Extension of the principle

The azimuthal disturbances of the vessel, on board which the experiment was made, were, however, still existing, and were prejudicial; but these have since been likewise corrected, as in the model which I have now the

* This was in a voyage to *Teneriffe* in 1856, on board the iron-built yacht, *Titania*, of 140 tons, most kindly lent by its owner, *R. Stephenson*, Esq., C.E., and M.P., for the occasion.

the honour of exhibiting before the Chamber, by the introduction of a second wheel, revolv-



The compound free-revolver stand

ing, and "freely," in a plane at right angles to the first.*

The

* The large machine thus improved, I had an opportunity of trying approximately in a day's sail to the *Bell-rock* Lighthouse, on board the official

The result of this compound application of free-revolution is, that, let a telescope be pointed in any direction, say to a certain star, then no matter what the angular disturbances of the ship may be, in direction or amount, they are all eliminated, and for practical purposes, perfectly; with an energy, too, and a success, that really seem to rise with every occasion for their display.

Working model exhibited

To enable the Chamber to judge; I set the wheels in rotation; and then, no matter what rolling,

official Steam-yacht, *Pharos*, in *October* 1858, through the kindness of *Robert Hunter*, Esq., Sheriff of *Bute*. This gentleman, who had also obtained me a similar opportunity for testing my earlier models in *November* 1855, had from the first entertained such warm hopes of, and intelligent scientific interest in, the naval application of "free-revolution," that on each occasion, the moment I was ready for a trial, he went immediately to the *Board of Northern Lights* (a Board whose appreciation of science has been so indubitably exhibited by the high character which they succeeded in giving to the *Scottish* Lighthouses during the time that they were under their undivided control), and obtained their permission and countenance towards my making the experiments on board their well-appointed vessel; and much am I indebted to the courtesy, friendly zeal, and assistance displayed by the captain, officers, and crew.

rolling, pitching, or yawing motions, quick or slow, are given to the stand, the telescope tube points all the time in one and the same angular direction in space; the most violent "lurches" are given to the stand; it is capsized, or spun round, over and over again, and finally, it is taken up in the hands and shaken with the utmost violence,—but during all these disturbances, the two wheels retain their angular planes, and the telescope its angular position, without the smallest appreciable oscillation or sensible wavering.

Its successful action, under the most violent disturbances

I am particular in drawing attention to the behaviour of the apparatus under all extremities and irregularities of treatment, because they are precisely what no pendulum steadying plan or any thing else yet tried at sea, can withstand in any degree; and it is from blindly concealing from themselves that ships' movements on the open ocean are irregular, unceasing,

unceasing, and occasionally extremely violent, that inventors of the seventeenth and eighteenth centuries, as well as some few resuscitators in the nineteenth, have so often fancied that they have reached practical success, by mere suspension or floatation.

Even one of the ablest of those eminent men,* who did take into account, that occasionally a ship gets a terrible "send," yet plumes himself, the natural action of his pendulum is such, that *continuo ad quietem perpendiculumque suum revertat;* and seems entirely unaware, that such an opportunity for any pendulum to recover itself, never exists at sea, even for the tenth part of a second.

Unceasing nature of a ship's angular movements, on an ocean voyage

A most wearying, but most instructive, occupation, indeed, it is, to watch the tops of the masts of a ship against the sky, during a long voyage; and see how, week after week, and month

* *M. Chr. Huyghens* of *Zulichem.*

month after month, not even during a calm, are they stationary for a single moment; and how intensely full of unrest are they, "*navim jactantibus austris;*" or, under the very circumstances, to which any instrumental method of correction, should most particularly be capable of applying.

The compound free-revolver stand corrects *all* angular deviations of a vessel

Now, it is precisely under such conditions that the rotatory machine just exhibited before the meeting, if only preserved from the action of wind, for which a piece of canvas, or a deal board, perfectly suffices, — comes out most powerfully in its ability to preserve itself and any thing attached to it, from all angular variation. Not only, too, be it observed, variations from the vertical plane, or those caused by pitching and rolling, which were all that the numerous pendulum methods ever attempted to cure; but equally the variations arising from "yawing," or occurring in the azimuthal

thal direction; and which it never entered into the minds even, of any of the plumb-bob, or fluid-floatation, inventors, to hope to correct.

A glance at the future, of free-revolver stands on board ship

Hence, gentlemen, I do trust, that besides this machine having brought to pass something which is decidedly new on board ship, it has also achieved an absolutely necessary first step, towards altitude measures at sea without reference to the natural horizon. And although there is much that I should be glad to communicate relative to the best form, as indicated by experiment, for the different parts of the apparatus, and likewise to enter into the refinements of the peculiar *anti-translation* gravity-indicator soon to be used in conjunction with it,—still, the unconscionable length of time that I have been occupying the Chamber, as well as the impropriety of speaking too confidently of machinal applications before they have been fully tried in practice,—induce me only to

to request the further attention of Members to certain changes, which the already proved characteristics of the free-revolver stand may tend to bring, or require to be brought, about, in what has been, I believe, for a long period a very general rule between captains and ship-owners.

Statement of the case

The case is this,—according to the present system of astronomical observation at sea, where every thing that is to be done, is accomplished with a sextant held in the hand, the size and weight, as well as expense, of the instrument, are necessarily restricted to very narrow limits. Hence has grown up the custom, of the captain, and not the owners, furnishing the angular instruments by which the ship is to be navigated.

But when once the method of the free-revolver stand is introduced, all the present necessity

Preparations to be made for a change in the size and character of instruments, now used in Nautical Astronomy

necessity for lightness and portability, will disappear; and it will become possible, increasing the dimensions and power of the stand accordingly, to employ large-sized telescopes, with all their manifold advantages; and to approximate, indeed, to the characteristics of a land observatory. In such case, it can hardly be insisted on, that the captain shall continue to furnish the astronomical instruments for the voyage; for they will necessarily become as much an integral part of the ship, as the anchor itself. And seeing that the owner, on principle, invariably furnishes the latter, why should he not supply the former also? While if, in fitting out the vessel, there should be a large sum to be set down for a permanent rotation apparatus, driven, perhaps, by a band from a steam-engine, and placed inside a small observing house on deck, where observer and instrument may both be sheltered from wind and

and weather,—will there not be increased security to the ship, as well as to the lives, and property of all on board?

Conclusion

There is much change, Mr President, I am aware, of established regulations, inferred in the above sketch; and deliberate counsel is necessary before attempting any alteration. But such change as shall prove to be required, will, I feel confident, be favourably entertained in the ripeness of time, by the ship-owners of the *Edinburgh* Chamber of Commerce; and, accordingly, as they order it, will they have an opportunity of exercising a powerful influence, in accelerating or retarding, the successful inauguration for the world, of the fifth age of the Longitude question at sea.

Edinburgh: Private Press of Peter Lawson & Son.

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Smyth, Charles Piazzi
Present state of the longitude question in navigation.

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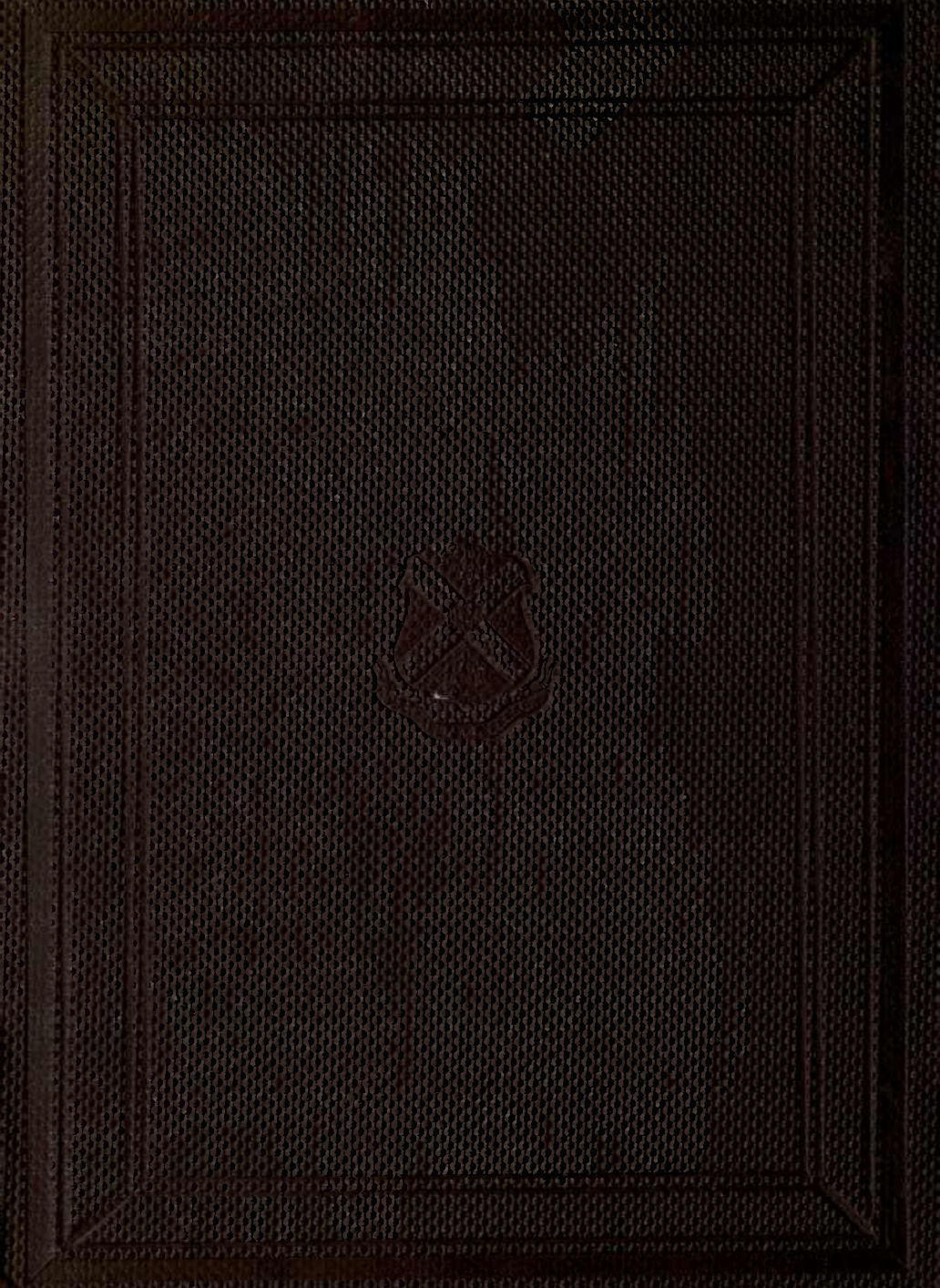
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